SCIENTIARUM POLONORUM ACTA
Acta Sci. Pol. Zootechnica 22(1) 2023, 53–62
www.asp.zut.edu.pl pISSN 1644-0714 eISSN 2300-6145 DOI: 10.21005/asp.2023.22.1.06

ORIGINAL PAPER
Received: 28.03.2023
Accepted: 26.05.2023

THE QUALITY OF EGGS DERIVED FROM POLBAR AND GREENLEG PARTRIDGE HENS – POLISH CONSERVATIVE BREEDS

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ABSTRACT

The intensive breeding work has led to the globalisation of poultry production in terms of available commercial hybrids of laying hens. However, the indigenous breeds are still maintained in many countries, including Poland. The experimental aim was to characterise the eggs quality from two local, Polish hen breeds: Greenleg partridge (Gp) and Polbar (Pb). 4145 eggs were analyzed, at 33rd and 53rd week of the birds' age. Pb eggs were characterized by the bigger shell and yolk proportion, bigger albumen height, bigger and more intensively coloured yolk as well as better shell quality manifested in its significantly higher density and breaking strength. The Gp eggs quality is evidenced by a fatty acid profile, lower thrombogenic index, triglycerides and cholesterol concentration. The high quality of eggs, the cultural and ethical conditions, allow us to hope for a wider use of these genotypes in the production of high-quality eggs.

Key words: biodiversity; animal genetic resources; in situ conservation; local breeds

INTRODUCTION

There are more than 23 billion farming birds counted as poultry in the world, which is about three birds per person [Mottet and Tempio 2017] and about five times more than 50 years ago. In an age of globalisation of breeding and consolidation of farming operators, most production is based on similar bird genotypes. Production is dominated by large poultry breeding centres, carrying out genotype-based breeding work on 10% of breeds classified as 'international' because they are found in various parts of the world [Rischkowsky and Pilling 2007]. However, there are still around 7,000 mostly local poultry breeds, which are niche products in the age of globalisation. Recently, local, often small populations, are increasingly being targeted by farmers [Lordelo et al. 2020]. This is due to several aspects. In many countries, mainly in Europe, there is a noticeable transformation of livestock systems towards more extensive agroecology [Gautron et al. 2022, Phocas et al. 2016a, Phocas et al. 2016b], where the basic characteristics of poultry are health, disease resistance and behaviour and welfare, while productivity is given a further place [Phocas et al. 2016a]. This places local breeds of hens above high-producing hybrids, which are worse adapted to local environmental conditions [Brunberg et al. 2014].

In addition, the long-term selection of commercial hen genotypes targeting the number of raw materials produced (eggs or meat) through selection egoism has led to a deterioration in their quality, while local breeds with lower selection pressure continue to produce good quality products [Sirri et al. 2018] from extensive rearing systems, which increasingly meets consumer acceptance despite the higher price [Żakowska-Biemans and Tekień 2017]. It is worth paying attention to birds of local breeds not only in the context of protecting valuable genetic resources but also as a source of good quality products [Sirri et al. 2018].

Several works have shown that genotype can influence productivity, but also the quality of the raw material obtained. The genetic-dependent variability was found not only in quality traits [Rakonjac et al. 2021] but also in the chemical composition including [Nishimura et al. 2021]. The growing interest in regional products has introduced a new research trend. Scientists from many countries conducting work on the quality of raw materi-

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als from local breeds have shown that chicken eggs from indigenous breeds have slightly better quality parameters [Sinha et al. 2018, Lordelo et al. 2020].

At the moment, there are three breeding laying hen farms in Poland with 12 hen strains (6 breeds), while the "Programme for the conservation of genetic resources of laying hen populations" covers 8 poultry breeds with 13 strains [Calik and Obrzut 2023], most of which have been included by the FAO in the world genetic resources to be conserved. Most poultry breeding populations are based on breeds brought to Poland several decades ago. The only Polish autochthonous breed can be considered to be the Greenleg partridge (Gp, Zk and Z-11 strains), which historically occurred on Polish territory. Two other Polish breeds are the Polbar (Pb strain) and the Yellowleg partridge (Ż-33 strain), both of which arose through the consolidation of crosses between Greenleg hens and Barred Plymouth Rock (Pb) and New Hampshire (Ż-33) cocks.

The Greenleg partridge hens of the Zk strain is the oldest closed population of hens in Poland being kept at the same farm since 1945. The closed for 70 years population and the lack of selection to improve production traits makes the Gp the primary population of this breed. A standard for this breed was established in 1923. The Gp was a general-purpose hen breed popular in farm management in south-eastern Poland at the turn of the 20th century, it accounted about 30% of the hen population in by the 1960s, however, in 1970s it was only 1–2%. Currently, the breed is slowly recovering in popularity and returning to the consumer's favour. Their on the retail market achieve prices almost twice higher than those from the commercial hybrids. The advantage of Gp hens is their excellent adaptation to extensive free-range farming conditions and their resistance to diseases [Siwek et al. 2013, Marchewka et al. 2020]. The birds are characterised by their relatively light body weight, which at 20 weeks of age is about 1400–1500 g in hens and 1800–1900 g in cocks, respectively. At this weight, the birds lay small eggs of about 46 g at the 33rd week of age, with a low laying rate of about 160 eggs by 56 weeks of age (own performance evaluation data).

Polbar (Pb strain) is the only Polish hybrid autosexing breed, created between 1946 and 1954 by Professor Laura Kaufman (the first female professor of zootechnics in Poland, member of the Polish Academy of Sciences) and since then maintained in the only breeding population at the University of Life Sciences in Lublin. The base material for its creation was Gp hens and Barred Plymouth Rock cocks [Gryzińska and Niespodziewański 2009]. Polbar belongs to the light, general-purpose breeds. At the 20th week of age the cocks reach a body weight of approx. 2000 g and the hens 1600 g. The annual laying rate is about 160 light cream-coloured eggs weighing 48 g at 33 weeks of birds' age (own performance evaluation data. The birds of this breed are characterised by good health, mild temperament and good adaptation to Central European environmental conditions, and their undoubted advantage is the possibility to recognise the sex of one-day-old chicks by the colour of their own [Gryzińska et al. 2014]. Both the Polbar and Greenleg partridge are not subject to selection to improve their performance and the breeding work is based on conserving the birds according to the breed standard.

Considering the uniqueness of the breeds included in the study (Polbar is the only population in the world), as well as the very limited documentation, mainly on the quality of the raw materials obtained, and at the same time the growing interest of consumers and many myths about local breeds, the current study was undertaken. The aim of the study was to characterise and compare the quality of eggs of two local Polish hen breeds: the Greenleg partridge and the Polbar.

MATERIAL AND METHODS

According to the Polish legislation (Act of 15 January 2015 on the protection of animals used for scientific or educational purposes, Journal of Law 2015 item 266) research assessing the quality of table eggs does not require the consent of the Ethical Committee. The material for our study was eggs obtained from the breeding stocks. Any procedures on birds were conducted and only eggs obtained from them were analysed .

The study included eggs from 2 hen breeds: the Greenleged partridge (Zk strain) and the Polbar (Pb strain) represented the native Polish breeds intended for extensive production. Gp and Pb as conservation stock for more than 70 generations, with no adding of new genes, are kept at the Laura Kaufman Didactic and Research Station for Small Animals at the University of Life Sciences in Lublin. During the production period birds were fed a standard complete feed mixture with the following basic composition: ME 11 MJ per kg, crude protein 16.72%, crude fat 3.4%, crude fibre 7.15%, crude ash 5%. The 16-hour lighting day was used for all breeds. All hens were kept on the litter, in a windowless building, each strain in 4 pens of about 250 birds at a stocking density of about 5 hens per m^2. The active populations of the Gp and Pb consist of about 1200 birds each.

A total of 4145 eggs were analysed, about 1000 from each breed, at 33 and 53 weeks of the birds' age. Eggs were collected in 2 consecutive days randomly, from each stock, and then analysed directly (on laying day). Egg content quality traits were determined using a set of egg quality assessment equipment (TSS, York, UK) consisting of a microprocessor (EQM+), 2 electronic scales (NavigatorXT, and KERN), an electronic colorimeter (QCC) to measure egg yolk colour according to the Roche 15-point scale and a micrometer screw to measure shell thickness. Reflectometer (QCR) was used for the eggshell colour measurement.

Each egg was analysed to determine: the egg shape index (EI) as the ratio of the short axis to the long one of the egg measured with an electronic calliper with an accuracy of 0.01 mm and the egg weight (EW) by an electronic balance with an accuracy of 0.01 g. The specific gravity of the egg (SG) was calculated according to Archimedes' principle based on the measurement performed on a scale with hanging registration WPS 1200/C (RadWag).

The breaking strength (SS) of the shell was determined with an accuracy of 0.01 N using an Instron Mini 55 apparatus (Instron, Norwood, MA, USA). The loading force at a constant displacement speed of the measuring head of V = 50 mm · min^{-1} was used as the evaluation criterion. Shell thickness (µm) was measured by two methods as non-destructive shell thickness (NST) using the EGG Shell Thickness Gauge (ESTG-1) 'Orka' (ORKA Food Technology LLC Suite #4, Utah, USA) ultrasonic material thickness measuring instrument and shell thickness measured after egg breakage using an electronic micrometer screw in the central part of the egg's long axis (ST). The measurement, due to its high repeatability, heritability and correlation with the micrometer screw measurement [Kibala et al. 2015], was performed at a position of 45° from the blunt end of the egg. In addition, the shell (density) (SD) was calculated according to the formula:

$$SD = \frac{sw}{3.9782MJ^{0.7056}}1000$$

The albumen height (AH) was measured using dense albumen height measurement devices (QCH) and Haugh units (JH) [Haugh 1937] were calculated. The yolk (YW), albumen (AW) and shell with membranes (SW) weights were determined on a WPS 1200/C electronic balance (RadWag, Radom, Poland) with the accuracy of 0.01 g and the proportion of yolk (YP), albumen (AP) and shell (SP) concerning the egg weight (EW) was calculated.

During the first quality assessment (at the 33rd week), 15 egg yolks of each breed were taken during destructive analysis. They were subjected to lipid profile evaluation. The level of cholesterol and triglycerides in the yolks of the tested eggs was determined by the colorimetric method [Washburn and Nix 1974] using a commercial analytical kit from Biomaxima (Lublin, Poland) according to the reagent manufacturer's recommendation. The fatty acid (FA) profile of egg yolks was analysed by gas chromatography according to PN-EN ISO 5508:1996 and PN-EN ISO 5509:2001. A Varian 450-GC gas chromatograph (Agilent Technologies, Santa Clara, CA, USA) with a flame detector (FID) was used for the analyses. Based on the proportions of individual acids and their groups, the following indices were calculated: PI – peroxidizability index [Arakawa and Sagai 1986], AI – atherogenicity index and TI – thrombogenic index [Ulbricht and Southgate 1991], DFA – desirable fatty acids [Medeiros et al. 2014], HFSA – hypercholesterolaemic saturated fatty acids [Renna et al. 2012] and h/H – hypocholesterolaemic / hypercholesterolaemic ratio [Domaradzki et al. 2019]. It was decided to perform the analysis of yolks' chemical composition only in the peak production due to it is typical term of egg sampling.

The statistical analysis used GLM procedures of SAS (Statistical Analysis System) software ver. 9.4. The normality of the data distribution was assessed using the Shapiro-Wilk test. The significance of differences between the mean of egg quality traits was verified by two-factor analysis of variance with Tukey's test (proc GLM). Laying age (33 and 53 weeks) and birds' breed (Gp and Pb) were used as factors. The lipid profile and cholesterol content of egg yolks were analysed using one-way analysis of variance with Tukey's multiple comparisons test. A significance level of $P \leq 0.05$ was adopted.

RESULTS

Egg quality traits depending on breed and age of birds are shown in Table 1. Significant effects of age, breed and their interaction on the majority of egg quality traits studied were observed. The interaction effect (age × breed) was not recorded only for specific gravity, albumen high and Haugh units, the age of the birds did not affect the proportion of shell to egg weight, while breed did not affect egg weight. Not considering the age of the birds, it can be stated that both breeds of hens lay similar shaped eggs, but at 33rd week, eggs from Polbar were significantly more rounded compared to eggs from Gp. With age, both breeds laid larger eggs with a more elongated shape. However, there was a significant interaction of age and breed, manifested by higher egg weight in GP compared to Pb at 33rd week of age, but considerably lower in Gp compared to Pb at 53 weeks of age. At both 33rd and 53rd week of age, Pb eggs were characterized by a lower specific gravity compared to Gp, and this trait decreased with age in both breeds. Analysis of egg percentage composition showed a significantly higher proportion of shell and yolk in the egg weight of Pb eggs in relation to Gp and a consistently significantly lower proportion of albumen in Pb vs. Gp. Irrespective of breed, there was a significantly higher proportion of yolk in egg weight in older birds and a consequently lower proportion of albumen compared to eggs from 33-week-old layers. Significantly higher albumen and therefore higher Haugh units were recorded in Pb, which was particularly evident at 33rd week of age. Although the same diet, significant differences in yolk colour were noticed, more intensively coloured yolks at 33rd week of age in Gp and at 53rd week of age in Pb. Without taking the age factor into

Table 1. The traits of eggs quality depending on the breed and the age of laying birds ($\bar{x}$ ± standard deviation)

Age		33 weeks		53 weeks		Effect of breed		Effect of age		P value		
Breed		Gp n = 1118	Pb n = 1119	Gp n = 1063	Pb n = 845	Gp n = 2181	Pb n = 1964	33 weeks n = 2237	53 weeks n = 1908	breed	age	age × breed
Whole egg	shape, %	75.4^{b}±2.8	75.9^{a}±2.9	74.5^{c} ±2.9	74.7^{c} ±2.9	74.9^{b}±2.9	75.3^{a}±2.9	75.7^{a}±2.9	74.6^{b}±2.9	<0.01	<0.01	<0.02
	weight, g	47.1^{c}±3.4	46.5^{d}±3.9	52,0^{b}±3.7	52.6^{a} ±4.1	49.6±4.3	49.3±4.9	46.8^{b}±3.6	52.3^{a}±3.8	<0.71	<0.01	<0.01
	specific gravity, g · cm^{-3}	1.082^{a} ±0.006	1.080^{b} ±0.007	1.079^{c} ±0.007	1.077^{d} ±0.006	1.080^{a} ±0.006	1.079^{b} ±0.007	1.081^{a} ±0.006	1.078^{b} ±0.007	<0.01	<0.01	<0.29
Share (%) of	shell	12.5^{b}±0.8	13.9^{a}±1.1	12.6^{b} ±1.1	13.8^{a} ±1.1	12.6^{b}±0.9	13.9^{a}±1.05	13.2±1.2	13.1±1.2	<0.01	<0.7	0.02
	albumen	58.1^{a}±2.5	55.1^{c}±2.9	55.3^{b}±2.4	52.9^{d}±2.8	56.7^{a}±2.8	54.1^{b}±3.1	56.5^{a}±3.1	54.2^{b}±2.9	<0.01	<0.01	<0.01
	yolk	29.3^{d}±2.2	30.2^{c}±2.2	31.7^{b} ±1.8	32.2^{a} ±1.9	30.5^{b}±2.3	31.1^{a}±2.3	29.7^{b}±2.2	31.9^{a}±1.8	<0.01	<0.01	<0.01
Albumen height, mm		5.2^{b}±1.04	5.3^{a}±1.2	4.7^{c} ±0.99	4.9^{c}±0.96	4.9^{b}±1.04	5.1^{a}±1.14	5.3^{a}±1.15	4.8^{b}±0.97	<0.01	<0.01	<0.98
Haugh units		75.2^{b}±7.9	76.2^{a}±8.9	69.9^{c} ±7.8	70.5^{c} ±7.6	72.9^{b}±8.2	73.7^{a}±8.8	75.7^{a}±8.5	70.2^{b}±7.7	<0.01	<0.01	<0.43
Yolk weight, g		13.9^{d}±1.5	14.2^{c}±1.7	16.6^{b}±1.4	17.3^{a}±1.5	15.3^{b}±1.9	15.7^{a}±2.2	14.1^{b}±1.6	16.9^{a}±1.4	<0.01	<0.01	<0.01
Yolk colour, pts		8.7^{c} ±1.6	8.4^{d} ±1.5	8.9^{b} ±1.2	9.1^{a}±1.2	8.8^{a}±1.34	8.5^{b}±1.5	8.5^{b}±1.6	9.1^{a}±1.2	<0.01	<0.01	<0.01
Shell colour, %		60.2^{b}±5.9	57.6^{d}±5.2	61.4^{a}±5.7	58.9^{c}±5.6	60.4^{a}±5.9	57.8^{b}±5.6	58.9^{b}±5.7	60.2^{a}±5.8	<0.01	<.001	0.55
Shell weight, g		5.9^{c}±0.5	6.6^{b}±0.8	6.5^{b}±0.6	7.5^{a}±0.9	6.2^{b}±0.65	7.1^{a}±0.9	6.3^{b}±0.7	6.9^{a} ±0.8	<0.01	<0.01	<0.01
Shell non-destructive thickness, μm		425.8^{a} ±35.1	394.6^{b} ±33.7	403.5^{b} ±34.1	405.7^{b} ±36.1	408.9 ±36.1	401.7 ±36.1	412.2^{a} ±34.5	409.6^{b} ±35.3	<0.33	0.01	<0.01
Shell thickness, μm		301.9^{a} ±27.4	298.1^{b} ±28.8	295.9^{b} ±33.6	297.6^{b} ±32.3	299.6 ±30.6	298.1 ±30.2	300.1^{a} ±28.2	296.7^{b} ±33.1	<0.25	<0.01	<0.01
Shell density, mg · cm^{-2}		97.7^{d} ±6.4	111.0^{b} ±10.6	101.4^{c} ±8.3	114.3^{a} ±11.2	99.7^{b} ±7.6	112.2^{a} ±10.9	104.4^{b} ±11.1	107.1^{a} ±11.6	<0.01	<0.01	0.42
Shell breaking strength, N		37.8^{b}±7.9	43.6^{a}±9.7	35.4^{b}±8.1	44.4^{a} ±9.7	36.6^{b}±8.1	43.7^{a}±9.7	40.7^{a}±9.3	39.5^{b}±9.9	<0.01	<0.01	<0.01

$^{a, b, c, d,}$ – means in the rows in the different sectors of table differ significantly at P ≤ 0.05 (Tukey test); Gp – Greenleg partridge, Pb – Polbar

consideration, eggs of the Gp breed had more intensively coloured yolks.

For most shell quality traits, they were significantly influenced by birds' age, breed and the age×breed interaction (Table 1). There was no effect of interaction in the case of the shell colour and its density and breed in the shell thickness. The Gp laid eggs with significantly lighter shells compared to the Pb. Regardless of breed, eggs laid at 53rd week were also characterized by lighter shells than those from younger birds. Both breeds were characterized by a similar eggshell thickness, although at 33rd week Pb had significantly thinner shells compared to Gp. In contrast, the better quality of the Pb shell relative to the GP was indicated by significantly higher density and breaking strength. Regardless of breed, shell thickness and breaking strength decrease with age, but density increases.

There were no significant differences between Pb and Gp in the PUFA fatty acids (Table 2). However, Pb, in comparison to Gp, had a significantly higher proportion of saturated acids: C14:0 – myristic acid and C16:0 – palmitic acid and monounsaturated fatty acids: C14:1 – cis-9-tetradecenoic acid, C16:1 – palmitoleic acid. Significantly higher values of atherogenicity index and hypercholesterolaemic saturated fatty acids were recorded in the Pb compared to Gp. In contrast, the Gp breed was characterised by significantly higher desirable fatty acids and hypocholesterolaemic / hypercholesterolaemic ratios than Pb.

The cholesterol and triglyceride content of egg yolks was also analysed (Fig. 1). It was found that, in the case of cholesterol, eggs obtained from Greenleg partridge had significantly the lower content than Polbar. Similar observations also apply to the triglyceride content, their lower level characterised egg yolks from Gp.

DISCUSSION

The first fundamental feature distinguishing eggs of indigenous breeds is the egg weight. Conventionally, selection for higher egg weight can reduce body weight and to improve feed efficiency [Altan et al. 2004]. Both breeds

Table 2. The fatty acid profile (%) in egg yolks depending on the breed of hens ($\bar{x}$ ± standard deviation)

Trait, %	Breed		P value	Trait	Breed		P value
	Gp, n = 15	Pb, n = 15			Gp, n = 15	Pb, n = 15	
C14:0	0.260^{b} ±0.019	0.316^{a} ±0.034	0.001	SFA	28.20 ±0.772	29.03 ±1.165	0.116
C15:0	0.063 ±0.007	0.074 ±0.017	0.103	MUFA	43.39 ±1.666	42.65 ±2.358	0.478
C16:0	20.86^{b} ±0.764	22.05^{a} ±1.195	0.031	PUFA	22.74 ±1.682	22.36 ±3.010	0.757
C18:0	6.996 ±0.369	6.558 ±0.639	0.114	n3	0.939 ±0.104	0.913 ±0.182	0.728
C20:0	0.022 ±0.004	0.021 ±0.004	0.841	n6	21.80 ±1.586	21.44 ±2.835	0.759
C14:1 n5	0.036^{b} ±0.007	0.054^{a} ±0.013	0.005	n9	41.32 ±1.765	39.87 ±2.358	0.184
C16:1 n7	1.995^{b} ±0.164	2.648^{a} ±0.470	0.002	n3:n6	0.043 ±0.002	0.042 ±0.004	0.651
C18:1 n9c + C 18:1 n9t	41.339 ±1.736	39.865 ±2.353	0.176	PI	28.62 ±2.798	28.51 ±4.447	0.952
C18:2 n6c + C 18:2 n6t	20.136 ±1.469	19.705 ±2.433	0.674	AI	0.331^{b} ±0.017	0.359^{a} ±0.027	0.025
C18:3 n6 γ	0.070 ±0.014	0.050 ±0.052	0.803	TI	0.794 ±0.038	0.832 ±0.057	0.133
C18:3 n6 α	0.919 ±0.102	0.891 ±0.175	0.707	DFA	73.13^{a} ±1.226	71.56^{b} ±1.569	0.043
C20:2 n6	0.226 ±0.027	0.203 ±0.049	0.248	HSFA	21.12^{b} ±0.768	22.37^{a} ±1.209	0.027
C20:3 n6	0.127 ±0.018	0.117 ±0.026	0.466	h/H	3.031^{a} ±0.165	2.784^{b} ±0.224	0.025
C 20:4 n6	1.427 ±0.193	1.546 ±0.119	0.191				
C20:3 n3	0.020 ±0.001	0.021 ±0.004	0.337				
C22:2 n6	0.068 ±0.034	0.063 ±0.013	0.701				

$^{a, b, c}$ – means in the rows differ significantly at P ≤ 0.05 (Tukey test); breeds: Gp – Greenleg partridge, Pb – Polbar; SFA – saturated fatty acids, UFA – unsaturated fatty acids, PUFA – polyunsaturated fatty acids, MUFA – monounsaturated fatty acids; C14:0 – myristic acid, C15:0 – pentadecylic acid, C16:0 – palmitic acid, C18:0 – stearic acid, C20:0 – eicosanoic acid, C14:1 – cis – 9 tetradecenoic acid, C16:1 – palmitoleic acid, C18:1 – oleic acid, C18:2 n6 – linoleic acid (LA), C18:3 n6 – γ – linolenic acid (GLA), C18:3 n3 – α – linolenic acid (ALA), C20:2 – 8,11 eicosadienoic acid, C20:3 n6 – dihomo-γ-linolenic acid, C20:4 n6 – arachidonic acid (AA), C20:3 n3 – cis 11,14,17 eikcosatrienoic acid; C22:2 – docosadienoic acid; SFA – saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, PI – peroxidizability index, AI – atherogenicity index, TI – thrombogenic index, DFA – desirable fatty acids, HFSA – hypercholesterolaemic saturated fatty acids, h/H – hypocholesterolaemic / hypercholesterolaemic ratio.

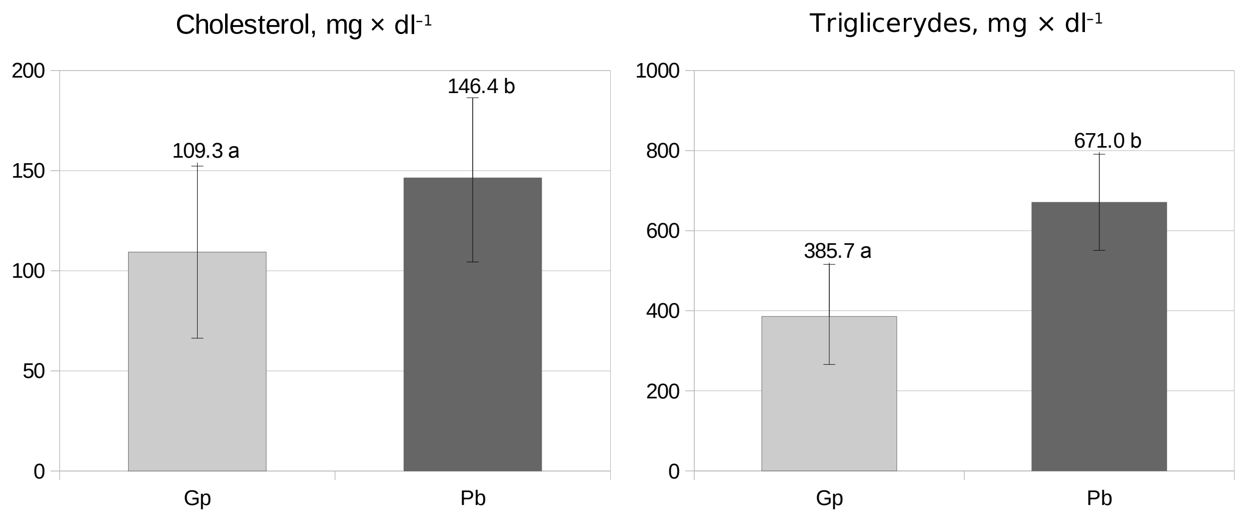

Fig. 1. The cholesterol and triglycerides levels in yolks depending on the hens' breed ($\bar{x}$ ± standard deviation)

$^{a, b}$ – means differ significantly at P ≤ 0.05 (Tukey test), Gp – Greenleg partridge (n = 15), Pb – Polbar (n = 15)

(Gp and Pb) demonstrate relatively low body weight but their egg weight even at the end of the 1st year of production classifies this raw material in the S egg class (<53 g). This is a huge technological obstacle because with standardised egg boxes, there is a high risk of these eggs moving too freely during transport, which can result in a high number of breakages [Hamilton et al. 1979]. At the same time, the shape of the egg, despite the demonstrated differences between the breeds, is within the standards for consumer hen eggs. In addition to this fact, two more negative consequences of low egg weight should also be mentioned. Firstly, the price of S-class eggs is low. Secondly, sorting plants are often refusing eggs at such low grading. The effect of this situation is that locally produced eggs from the Gp and Pb stock are distributed directly between producers and consumers, bypassing additional elements of the supply chain. This also has a positive aspect, as bypassing the middlemen, the raw material obtained can be sold more expensively. At this point, it is also important to note the differences between the various lines of Greenleg partridge. The Zk strain, analysed in this study, lays eggs with an average weight of 47.1 g at the 33rd week of life, while the Z-11 strain, at the same age, lays heavier eggs weighing 53.5 g [Krawczyk 2017]. In the 53rd week of life, the egg weight of the Zk strain was 52 g, while that of the Z-11 strain amounted from 56.7 [Sokołowicz et al. 2019] to 58.5 [Krawczyk et al. 2023]. However, the weight of laying hens of both strains in the 20th week of life is similar. The Greenleg partridge Z-11 strain was established in 1972, among others based on the oldest Zk strain. As a consequence of the separate management for more than 50 years as two different populations of the same breed, the changes in their performance traits are visible.

Our results do not confirm the relationship reported by Nordstrom and Ousterhout [1982], who found that specific gravity and shell proportion decreased for eggs that differed in weight but had the same shell thickness. This may be because they worked on genetically standardised material, whereas in our work 2 different not selected breeds of hens were used, hence the correlations obtained may largely be due to differences in genetic determination concerning breed.

Analysing the proportion of particular egg elements, it is noticeable that the proportion of yolk amounted about 30%. Similar results were also reported by other authors [Sokołowicz et al. 2018, Fathi et al. 2021] while in some works this trait in eggs of the commercial strains is reported at 25–26% [Wu et al. 2007] or 25–27% [Wengerska et al. 2023]. The Rhode Island Red and Rhode Island White breeds, used globally for laying production, have a yolk percentage as 26.5% of egg weight at the 33rd week of life [Calik and Obrzut 2023]. In unselected local Italian hen breeds, the yolk percentage per egg was 31.1% compared to 24.9% in commercial high-producing hybrids [Sirri et al. 2018]. This fact is in favour of eggs from indigenous breeds as most of the egg's nutrients are contained in their yolks [Krawczyk 2017], as well as it can be assumed that high selection pressure on egg weight results in genetic progress expressed by an increase in albumen weight. Consequently, a higher egg weight gives a higher egg price but this is not directly proportional to the higher nutrient content which is largely deposited in the egg yolk.

Both breeds showed a decrease in albumen height and consequently, Haugh units with age, which is in line with the results of other authors [Williams 1992, Kowalska et al. 2021]. The higher albumen and Haugh unit values were recorded in Pb than in Gp eggs, however, this is most likely due not to the size of the egg but the genetic differences between the hen breeds analysed because, as noted by other authors [Silversides et al. 1993, Silversides and Villeneuve 1994], Haugh units correlate much more strongly to albumen height than to egg weight. The relatively low albumen height in our breeds (Gp and Pb) hens may be a discouraging factor for consumers to purchase this raw material, although it is not indicative of the quality of these eggs.

Both, Gp and Pb breeds lay eggs with light-coloured, creamy shells although substantially different in colour from the brown shells of the high-producing commercial hybrids. Polbar has the darker shells but this is due to the paternal component of Barred Plymouth Rock birds (laying brown-shelled eggs) used in the creation of this breed [Gryzińska and Niespodziewański 2009]. The shell colour of Polish hen breeds can be a diagnostic trait to verify their genetic origin. This can be very important in order to control unauthorised breeding material of questionable quality, often damaging the image of licensed breeders. Recently, Greenleg partridge eggs as a Polish breed have become very fashionable. They reach prices almost twice as high as those of commercial hybrid eggs. This situation has led to the appearance of brown-shelled eggs affiliated to the Gp breed, where the colour alone excludes this origin. They are likely produced by hybrids with a maternal component of Greenleg partridge.

The parameters characterising shell quality of both breeds eggs were at a satisfactory level. Shell thickness decreases with birds' age [Sokołowicz et al. 2018, Sokołowicz et al. 2019], also a decrease in shell strength with age [Rodriguez-Navarro et al. 2002, Sokołowicz et al. 2019, Calik and Obrzut 2023] was confirmed. In the case of Polbar, a slight (but insignificant) decrease in shell thickness with age, but it was also observed that shell density and strength increased with age in this breed. This may be partly explained by the use of the Barred Plyumouth Rock hen genotype during Polbar creation. Analyses of egg quality in 3 Barred Plyumouth Rock hen strains (P-11, WJ-44 and D-11) showed that shell density increases with age in laying hens and only a slight decrease in its strength and thickness (own data – unpublished).

The fatty acid profile is one of the more widely considered issues in the context of table eggs, due to its biological importance and its relatively simple modification. However, the vast majority of studies in this area focus on the effect of nutritional additives on the development of the fatty acid profile [Aguillón-Páez et al. 2020, Batkowska et al. 2021]. In the case of our study, fully standardised nutrition was used, so this factor was eliminated. The differences obtained therefore indicate a different deposition of particular fatty acids in the egg yolk of the birds from the various breeds. These observations seem to confirm the data presented by Lordelo et al. [2020] who, found differences in the fatty acid profile between Portuguese native breeds and birds kept on commercial farms. However, these authors found a slightly different relationship indicating higher contents of acids such as C14:0, C16:0 or C 20:0 in eggs of the indigenous breed, which in our study was confirmed only for Pb eggs. In turn, Gumułka et al. [2022] comparing the fatty acid profile of Polish chickens and Hy-Line layers did not indicate differences within saturated fatty acids, but the correlations they described in the context of MUFA are in line with our observations.

The proportion of particular FA influences the nutritional properties and biological effects of eggs as food. The best way to analyse these compounds is to determine the fatty acid indices. Studies indicate that some of these, like the fatty acids themselves, depend on the diet, although research by Sinanoglou et al. [2011] also indicates species variation. The AI and TI values are all the more important as they indicate the potential for stimulation of blood platelet aggregation. The values of these indices are highly significant, as an indicator of lipid quality, implying their role in shaping coronary artery disease. Logically, lower values of these indexes would therefore be recommended in the human diet. According to data presented by Fernandes et al. [2014] dietary recommendations indicate the need to limit raw materials with an AI of about 1 and a TI of about 0.5. The results obtained thus suggest that the norm for AI is maintained regardless of breed, while TI is elevated, although it should be stressed that, despite exceeding the recommendations, eggs from Gp and Pb birds were characterised by lower values of this index.

Hen eggs are a rich source of cholesterol, which, despite its significant biological functions, has been infamous for its association with the incidence of cardiovascular disease [Kannel et al. 1971]. This has been reflected widely in egg consumers. Probably because of this information, Gp eggs, which are known in Poland as eggs with reduced cholesterol content (as confirmed by our research), are gaining popularity. The differences between breeds observed in our study are consistent with those described by other authors for comparisons of commercial hybrids and autochthonous breeds [Ianni et al. 2021, Rizzi and Chiericato 2010]. A common feature of almost all local breeds is lower productivity compared to commercial hybrids, which may be one of the components, besides diet and housing system, of the altered lipid profile of the eggs obtained.

CONCLUSIONS

In terms of egg quality, indigenous Polish poultry breeds (Greenleg partridge and Polbar) are distinguished by their low egg weight, which can be a major technological problem in the supply chain to the final customer. However, the advantage of eggs from indigenous breeds is the high proportion of yolk. The better quality of eggs from native breeds is evidenced by their favourable fatty acid profile with a lower TI index and a significantly lower concentration of cholesterol in the egg yolk characterising eggs from Greenleg partridge. The high quality of eggs from the Gp and Pb breeds, cultural and ethical considerations, allow us to hope for a wider use of these genotypes in the production of high quality raw egg material.

ACKNOWLEDGEMENT

The work was not funded from external sources.

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JAKOŚĆ JAJ POCHODZĄCYCH OD KUR RASY POLBAR I ZIELONONÓŻKA KUROPATWIANA, POLSKICH RAS ZACHOWAWCZYCH

STRESZCZENIE

Intensywna praca hodowlana doprowadziła do globalizacji produkcji drobiu pod względem dostępnych komercyjnych mieszańców kur nieśnych. Jednak w wielu krajach, w tym w Polsce, nadal utrzymywane są rasy lokalne. Celem doświadczenia była analiza jakości jaj dwóch rodzimych, polskich ras kur: Zielononóżki kuropatwianej (Gp) i Polbara (Pb). Analizie poddano 4145 jaj w 33. i 53. tygodniu życia ptaków. Jaja rasy Pb charakteryzowały się większym udziałem skorupy i żółtka, wyższą wysokością białka, większym i intensywniej zabarwionym żółtkiem, a także lepszą jakością skorupy przejawiającą się istotnie wyższą gęstością i wytrzymałością na pękanie. O jakości jaj Gp świadczy profil kwasów tłuszczowych, niższy indeks trombogenności, stężenie trójglicerydów i cholesterolu. Wysoka jakość jaj, warunki kulturowe i etyczne pozwalają mieć nadzieję na szersze wykorzystanie tych genotypów w produkcji jaj wysokiej jakości.

Słowa kluczowe: bioróżnorodność; zasoby genetyczne zwierząt; ochrona in situ; rasy lokalne

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