EGG ALBUMEN QUALITY AS AFFECTED BY BIRD ORIGIN
KSZTAŁTOWANIE SIĘ JAKOŚCI BIAŁKA JAJA W ZALEŻNOŚCI OD POCHODZENIA PTAKA

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ABSTRACT

The purpose of study was to assess the effect of bird genome on egg albumen quality. Egg albumen harvested from seven local strains of laying hens: S-55, K-44, K-66, A-88, A-22, M-55 and V-44 were taken as experimental material. The main physical and chemical quality traits of egg albumen were determined. The percentage concentration and hydrolytic activity of egg albumen lysozyme was also examined. The study was conducted on eggs laid by hens at 36 weeks of age.

Eggs produced by M-55 layers demonstrated the highest percentage content of albumen (60.87%), the highest albumen height (9.01mm) and Haugh unit (92.80) as well as relatively high pH value (7.85). Egg albumen from A-22 layers was found to have not only the highest crude protein (10.58%0 and ash (0.97%) content but also the highest values of lysozyme concentration (5.14µg/ml) and hydrolytic activity (108746U/ml). Statistically significant differences ($p \leq 0.05$) were noted in the physicochemical traits of albumen from the eggs produced by the examined Polish strains of laying hens.

The experimental findings revealed that bird origin is an important factor affecting egg albumen quality.

Key words: egg albumen, genotype, physical traits, chemical traits, lysozyme

STRESZCZENIE

Celem badań było określenie wpływu genomu ptaka na jakość białka jaj. Materiał badawczy stanowiły białka jaj pochodzących od siedmiu krajowych rodów kur nieśnych: S-55, K-44, K-66, A-88, A-22, M-55 oraz V-44. Określono podstawowe parametry jakościowe białka jaj oznaczając jego cechy fizyczne i chemiczne. Przeprowadzono również analizy lizozymu białka jaja kurzego, oznaczając jego procentowe stężenie jak i aktywność hydrolityczną. Badania przeprowadzono w 36 tygodniu życia niosek.

Stwierdzono, iż jaja zniesione przez nioski M-55 wyróżniały się największym procentowym udziałem białka (60,87%), najwyższą wysokością białka (9,01mm), liczbą Haugha (92,80) oraz stosunkowo wysokim pH (7,85). W przypadku analiz chemicznych odnotowano, że białka jaj pochodzące od niosek A-22 charakteryzowały się nie tylko największą ilością białka ogólnego (10,58%) i popiołu (0,97%) ale i najwyższymi wartościami stężenia (5,14µg/ml) oraz aktywności hydrolitycznej (108746U/ml) lizozymu. Wykazano statystycznie istotne różnice ($p \leq 0,05$) w zakresie omawianych fizykochemicznych cech białka jaj pochodzących od badanych polskich rodów kur nieśnych.

Na podstawie uzyskanych wyników, stwierdzono, że pochodzenie ptaka jest istotnym czynnikiem wpływającym na jakość białka jaja.

Słowa kluczowe: białko jaja, genotyp, cechy fizyczne, cechy chemiczne, lizozym

STRESZCZENIE SZCZEGÓŁOWE

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W przypadku analiz chemicznych odnotowano, że białka jaj pochodzące od niosek A-22 charakteryzowały się nie tylko największą ilością białka ogólnego (10,58%) i popiołu (0,97%) ale i najwyższymi wartościami stężenia (5,14µg/ml) oraz aktywności hydrolitycznej (108746U/ml) lizozymu. Wysokie parametry lizozymu sugerują zasadność wykorzystania rodu A-22 do tworzenia komercyjnych mieszańców kur nieśnych, których jaja powinny zawierać więcej lizozymu, co może mieć szczególne znaczenie dla dalszego wykorzystania ich w przemyśle spożywczym, medycynie, farmakologii oraz weterynarii. Wykazano statystycznie istotne różnice ($p \leq 0,05$) w zakresie omawianych fizykochemicznych cech białka jaj pochodzących od badanych polskich rodów kur nieśnych.

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INTRODUCTION

Egg albumen is for the humans the most valuable kind of protein, and its amino acid composition is regarded as a standard. It is characterized by a unique biological value and its true digestibility (TD) is the highest one (TD=97% ± 3%) among the known protein foods [6].

Egg albumen shows great quantitative and qualitative diversification and is present in all structural parts of the egg. The highest protein content in the dry matter is in the egg albumen and in the outer and inner membranes whereas the lowest one in the egg shell [22]. The freshly laid egg contains: 80% water, 11% protein, 0.6% carbohydrates (glucose) and 0.4% minerals [37].

Due to the occurrence of biologically active substances in the albumen, first of all lysozyme (muramidase), albumen is a natural barrier and inhibits the growth and penetration of bacteria and moulds into the yolk [22]. Particularly high concentration of lysozyme in the chicken egg protects the embryo from infection prior to the production of its own immunoglobulins [13]. Apart from the preventive function of lysozyme, it is responsible for the gellous structure of albumen and thus indicates egg freshness. The gellous structure of the dense albumen fraction being the most important structural trait-is dependent on the stability of lysozyme with ovomucin complex. The highest stability of that complex is kept until the pH value of albumen is equal 9.2 and with the age of egg the pH value is increasing. At lysozyme pH 9.3 to 9.6 i.e. close its isoelectric point, the complex of lysozyme with ovomucin undergoes a complete dissociation, the albumen becomes thin and thus egg quality is decreased [8,9].

Lysozyme has nowadays been widely used in the food industry, medical diagnostic, methods veterinary medicine and pharmacology [3,14,20]. Due to its functional properties it often plays the role of a nutraceutic [34,10]. Lysozyme due to the antibacterial activity was declared in 1992 by the FAO/WHO Expert Commission as a safe compound [7]. That enzyme under the E1105 symbol was included into the group additives and acceptable substances to be used in the food processing industry and was specified in the Regulation of the Polish Ministry of Public Health of the 23 April 2004 [28].

The effect of bird genotype on egg albumen quality has for many years been known [12,27,26]. Despite the long lapse of time, that issue is a subject of numerous studies which have demonstrated that apart from the environmental factors, age, hygienic conditions, veterinary prophylaxis and nutrition, the origin of bird to a great extent affects egg content quality [29, 24, 4, 35, 19, 38, 25, 1, 5, 40, 41, 33].

The quality of egg albumen is dependent on numerous factors and evaluated as better having greater height and smaller surface area after shell removal. Those traits determine the usefulness of eggs for cold storage and processing [22]. Among many methods of egg albumen quality assessment, the determination of Haugh unit is the main criterion of egg quality being used in the international egg trade. The Haugh units from 79 to 100 demonstrate the best egg albumen quality [11].

The share of the Polish strains in the commercial table egg production in Poland has been diminishing over the

Table 1. Physical traits of egg albumen from selected Polish breeding strains of laying hens
Tabela 1. Wyniki badań fizycznych cech białka jaj pochodzących od wybranych polskich rodów hodowlanych kur nieśnych

CECHA/TRAIT	RÓD/STRAIN							
	S-55	K-44	K-66	A-88	A-22	M-55	V-44	Całość Total
N	100	100	100	100	100	100	100	700
Procentowy udział białka w jaju /% content of albumen								
x	60.23^{a}	57.79^{d}	57.95^{cd}	58.96^{bc}	59.94^{ab}	60.87^{a}	59.88^{ab}	59.37
s	4.95	3.72	3.51	5.33	3.25	3.15	2.82	3.92
v	8.2	6.4	6.1	9.0	5.4	5.2	4.7	6.6
SEM	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.15
Masa białka/ Albumen weight								
x	41.14^{a}	34.46^{d}	36.15^{c}	36.60^{bc}	36.92^{bc}	40.19^{a}	37.46^{b}	37.56
s	3.54	3.49	4.52	4.06	3.12	2.81	3.45	3.61
v	8.6	10.1	12.5	11.1	8.5	7.0	9.2	9.6
SEM	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.14
Wysokość białka/Albumen height								
x	6.91^{c}	7.99^{b}	8.13^{b}	7.96^{b}	8.36^{b}	9.01^{a}	7.99^{b}	8.05
s	1.03	1.44	1.48	1.39	1.36	1.45	1.62	1.40
v	14.8	18.0	18.2	17.5	16.3	16.1	20.3	17.5
SEM	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.05
Liczba Haugha/Haugh units								
x	80.04^{d}	88.66^{bc}	89.03^{bc}	88.10^{c}	90.53^{ab}	92.80^{a}	87.88^{c}	88.15
s	7.23	10.62	8.07	8.38	7.77	7.64	9.48	8.53
v	9.0	12.0	9.1	9.5	8.6	8.2	10.8	9.7
SEM	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.3
PH białka/Albumen pH								
x	7.78^{b}	7.08^{d}	7.18^{d}	7.17^{d}	7.45^{c}	7.85^{b}	8.01^{a}	7.50
s	0.44	0.60	0.44	0.50	0.66	0.57	0.54	0.54
v	5.7	8.5	6.2	6.9	8.9	7.2	6.8	7.2
SEM	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.02

number of years. That results from the dynamic changes observed in the local breeding farms of laying hens which dropped to three only]16, 17]. In those farms, the genetic improvement of the remaining breeding strains has been done, since they are not only a valuable gene pool but have also been used in the development of new breeding strains and of commercial hybrids of layers. Therefore it seemed to be justified to undertake a study aimed at the assessment of albumen quality traits in eggs from diversified breeding strains of laying hens. It was taken into consideration that the results of study will be distributed among breeding farms and used to adequately conduct selection in the breeding flocks and achieve commercial layers producing table eggs of high quality traits which will meet the requirements of the consumers.

The poultry production sector, in comparison with the other animal production sectors, demonstrates appreciable progress in the fields of genetic, nutrition and processing. The poultry breeds threatened nowadays by extinction are kept as gene pools which can be required in the future in the necessary expansion of the genetic variability of the current selection trends in the poultry breeding flocks.

MATERIAL AND METHODS

The egg albumen from seven Polish breeding strains of laying hens: A-22 and A-88 (Rhode Island White), K-44 and K-66 (Rhode Island Red) – Duszniki Wlkp. Breeding Farm; M-55 (Rhode Island White) and V-44 (Rhode Island Red) Laying Hen Breeding Centre in Mienia and S-55 (Sussex) – Laying Breeding Farm in Rszew was used as experimental material.

Albumen samples for experiments were taken from eggs laid by hens at 36 weeks of age. One hundred albumen samples were taken at random from each group of birds on the same day to standardize the experimental conditions. The determination of the physical traits of eggs comprised: albumen weight, height and pH; albumen percentage content in the egg; Haugh units. The examination of albumen chemical traits comprised: percentage content of crude protein by Kjeldahl method, acc. to PN-75/A-04018/Az3:2002 Standard; of water by PN-A-86509:1994 Standard, whereas of ash acc. to the method described by Krełowska-Kułas [18]. Moreover, the concentration and hydrolytic activity of lysozyme were determined [15].

The results of egg albumen examination of the physicochemical traits were subjected to the analysis of variance to confirm the difference in the studied albumen traits among the eggs from seven groups of layers. Simple correlation analysis was carried out to estimate the correlation among the studied traits within each group of birds. All the results were statistically analysed using Statistica 6.0 programme and one-way analysis of variance at the significant level of $p=0.05$ as well as Duncan's test.

RESULTS

The maximum difference in the percentage content of egg albumen amounted to 3.08% and the variation coefficient did not exceed 9.0% (Table 1). The observed differences were statistically significant at $p\leq0.05$.

The lowest weight of albumen (34.46g) was found in K-44 eggs, similarly as in the case of its percentage content. On the other hand, S-55 egg albumen demonstrated the highest weight (41.14g) and the differences among hen strains reached 6.68g. They were statistically significant at $p\leq0.05$, and the variation coefficient was rather high and ranged from 7.0 to 12.5%.

The greatest albumen height was noted in M-55 hen eggs (9.01mm) as well as greatest Haugh unit at the level of 92.80. Statistically significant differences at $p\leq0.05$ among bird strains were found and the maximum difference among strains attained 12.76.

The pH value was found to be the most equalized physical trait, and reached from 7.08 in K-44 egg albumen to 8.01 in V-44 egg albumen. The observed maximum difference was 0.93 and the variation coefficient did not exceed 8.9%. Ph value statistically significant differences were noted among the examined bird groups.

In Table 2 the chemical composition of egg albumen is shown. The highest crude protein content (10.58%) demonstrated the albumen from A-22 hen eggs and that value was statistically significant at $p\leq0.05$ in comparison with all other groups of birds. The highest water content in the albumen was found in K-44 eggs whereas albumen in V-44 eggs showed by 0.18% lower water content only. Both values were statistically significant as compared with the eggs of all other hen strains.

The albumen ash content was on relatively equalized level and the maximum difference was little more than 0.21%. However, statistically significant differences ($p\leq0.05$) were noted among A-22, V-44 strains and K-44; A-88; M-55 strains. Significantly lowest ash content in the albumen (0.76%) was found in K-66 hen eggs. Albumen water content was the most equalized chemical trait since the variance coefficient did not exceed 3.7%. In the case of ash and crude protein content they were on relatively high level and ranged from 11.9% (K-44) to 18.5% (S-55) and from 7.3% (S-55) to 15.3% (A-88), respectively.

The analysis of data pertaining to lysozyme in eggs from the examined hen breeding strains showed not only statistically significant differences, but also the effect of bird genome on the content of enzyme (Figure 1 and 2). Albumen of A-22 strain demonstrated both the highest concentration (5.14 µg/ml) and activity (108746 U/ml) of lysozyme. Slightly lower concentration of enzyme was noted in S-55 egg albumen but together with its high activity (104313 U/ml), too. Eggs of the other local hen strains demonstrated significantly lower ($p\leq0.05$) concentration and activity of the enzyme. Egg albumen from K-66 and V-44 strains was found to have the lowest concentration (3.93 µg/ml) as well as activity of lysozyme i.e. 83441 and 83243 U/ml.

Correlation coefficients (Table 3) were calculated among albumen weight and percentage content in the egg, pH value, crude protein content in the albumen and the other physicochemical traits of the albumen. Within the complete evaluation comprising all examined groups of birds the correlation coefficients ranged from -0.982 to 0.862.

DISCUSSION

In 1999 Tharrington and other scientists [36] evaluated the quality of egg albumen in birds of various genotype

Table 2. Chemical traits of egg albumen from selected Polish breeding strains of laying hens
Tabela 2. Wyniki badań chemicznych cech białka jaj pochodzących od wybranych polskich rodów hodowlanych kur nieśnych

CECHA/TRAIT	RÓD/STRAIN							
	S-55	K-44	K-66	A-88	A-22	M-55	V-44	Całość Total
N	100	100	100	100	100	100	100	700
Woda/% of water								
x	88.^{24bc}	89.22^{a}	88.74^{ab}	88.33^{bc}	87.88^{c}	86.95^{d}	89.04^{a}	88.34
s	0.78	1.25	1.09	1.62	0.92	3.24	0.77	1.80
v	0.9	1.4	1.2	1.8	1.0	3.7	0.9	2.0
SEM	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.09
Popiół /% of ash								
x	0.81^{bcd}	0.83^{bc}	0.76^{d}	0.86^{b}	0.97^{a}	0.81^{cd}	0.95^{a}	0.85
s	0.50	0.10	0.11	0.15	0.17	0.13	0.13	0.13
v	18.5	11.9	14.0	17.4	17.7	15.6	13.8	15.6
SEM	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Białko ogólne /% of protein								
x	10.37^{ab}	9.49^{d}	10.03^{bc}	10.28^{ab}	10.58^{a}	9.80^{cd}	9.64^{d}	10.03
s	0.76	1.12	1.03	1.57	0.91	0.78	0.75	0.97
v	7.3	11.8	10.3	15.3	8.6	8.0	7.7	9.7
SEM	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.05

and reported significant differences in their traits. The authors conducted their study on four lines of layers: CS5, CS7, CS10 and CCS. The egg albumen of CCS birds demonstrated: the highest Haugh unit (72.66), and weight (39.80g); percentage content in the egg (62.29%) and the lowest pH value (9.10). In our study the percentage content of lysozyme in the egg was by 1.88% lower, on average, and the pH by 1.62 lower. On the other hand, markedly higher Haugh units (by 18.68) were noted under the same mean albumen weight (37.56g). Moreover, in our study slightly lower, on average by 0.40%, crude protein content was noted.

The quality of egg albumen is illustrated, among others by albumen height and pH value, therefore those traits are used in the evaluation of egg freshness. Scott and Silversides (2000) [30] confirmed the genetic background of both albumen traits. In their study the eggs came from ISA-Brown and ISA-White laying hen lines. The albumen of ISA-Brown eggs showed higher pH value (8.74) but lower by 0.95 mm albumen height. In 2001 those authors [31] carried out an experiment on the same laying hen lines but taking also into consideration the age of birds. The ISA-Brown hens laid eggs of higher pH value in the range from 8.57 to 8.74 but of lower albumen height from 5.21 to 6.81 mm. Also in our study the brown feathered birds (K-44 and V-44) laid eggs of lower albumen height, by 0.41 mm on average, in comparison with the white feathered hens (A-22, A-88, M-55). On the other hand, no difference were observed in the pH value of albumen regardless of the color of bird feathering, white or brown.

In 2004 Silversides and Budgell [32] examined albumen quality from eggs laid by three lines of brown feathered hens: Brown Leghorn, ISA-Brown and Babcock. The highest pH value of albumen (8.84) was noted in Brown Leghorn eggs. Albumen height was found low in the range from 4.81 (Brown Leghorn) to 6.71 (Babcock). In our study the pH value of albumen in eggs from brown feathered birds ranged from 7.08 (K-44) to 8.01 (V-44) and thus were appreciably lower than the values reported by the authors cited above. On the other hand, albumen height in our study was lower by 2.10 to 4.20 mm.

Monira et al (2003) [21] conducted qualitative analysis of albumen in eggs from four strains of layers: Barred Plymouth Rock, White Leghorn, Rhode Island Red and White Rock. The authors reported that White Rock eggs showed the highest albumen height (4.66 mm) and Haugh unit (58.68). In our study those values were markedly higher by 4.35 mm and 34.12, on average, and thus demonstrated better quality traits of the analyzed

albumen. We also observed significant differences in the above traits when taking into consideration the origin of birds. Sussex hens laid eggs of the smallest albumen height (6.91 mm) and the lowest Haugh unit (80.04) while Rhode Island White hens were found to lay eggs of the highest albumen height (8.44 mm) and Haugh unit (90.50).

Differences in the pH value, albumen height and Haugh unit given in the literature and found in this study indicate that those traits are dependent on bird origin. Eggs laid by white feathered birds demonstrated by around two points greater albumen height and Haugh units. Such relationship has not been observed in the case of pH value. However, in many examined bird strains the higher pH values of lysozyme were associated with lower albumen height.

Apart from the main chemical composition of the egg, lysozyme content is an important constituent of the albumen. As early as in 1956 Wilcox [39] examined lysozyme content in the White Leghorn (WL) and Rhode Island Red (RIR) hen eggs and demonstrated a significant effect of hen breed on that trait. He found higher concentration of lysozyme in WL eggs than in RIR eggs. Similar results were reported by Bzdak (1997) [2] who observed in RIR birds and in Messa 245, Astra W and Astra S hybrids that lysozyme activity significantly varied and was dependent on bird origin. The highest enzyme activity was found in Astra S albumen and the lowest one in Messa 245 eggs. Statistically significant difference in that trait at $p \leq 0.05$ was noted among Astra S egg lysozyme and the other examined groups of birds. Noworyta-Głowacka (2005) [23] demonstrated the effect of genotype of Hy-Line and Tetra birds at 50 weeks of age on lysozyme activity.

In our study the highest activity of lysozyme was noted in the albumen of A-33 strain (108746 U/ml) and S-55 strain (104313 U/ml) eggs and the noted differences were statistically significant at $p \leq 0.05$ in comparison with all other examined bird strains. The highest lysozyme activity found in our study in A-22 egg albumen confirms the data reported by Bzdak and Noworyta-Głowacka. Both authors found a high lysozyme activity in Astra S egg albumen. Those birds are commercial hybrids formed on the basis namely: ♂K-64 x ♀A-82. Also in that case the quality of egg was affected by bird origin.

Despite the rather high differentiation of correlations among the analyzed traits in the experimental population, they were found significant ($p \leq 0.05$) for all examined traits. The physical traits of egg albumen in the S-55 strain demonstrated the highest number of significantly correlated characteristic and their value ranged from 0.263 (albumen weight x Haugh units and albumen height) to 0.862 (albumen weight x % of albumen). In the case of chemical traits the greatest number of significantly correlated characteristics was observed in A-88 breeding strain and their value ranged from -0.290 (crude protein in the albumen x lysozyme concentration) to 0.982 (crude protein in the albumen x water content in the albumen). Attention has to be drawn to the fact that A-22 egg albumen showed the greatest number of negatively correlated traits.

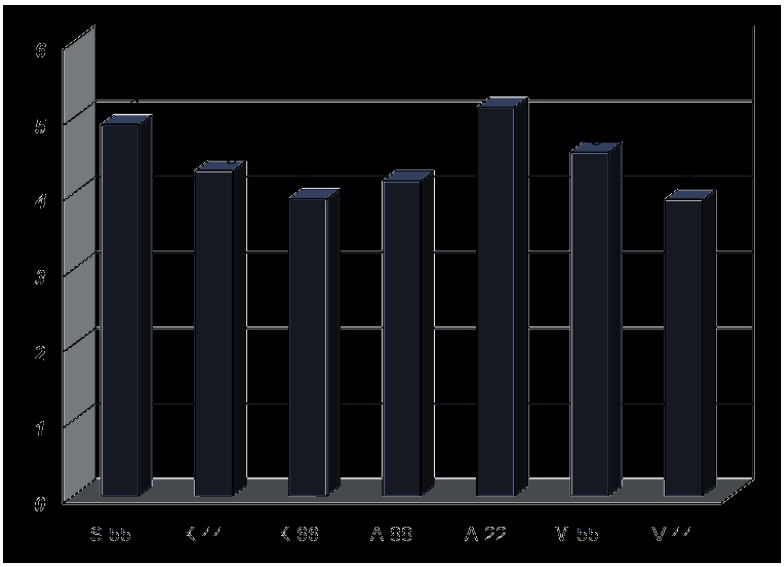

Figure 1. Comparison of the concentration of egg albumen lysozyme from selected Polish breeding strains of laying hens.

Wykres 1. Porównanie stężenia lizozymu białka jaj od wybranych polskich rodów hodowlanych kur nieśnych

Table 3. Correlations among certain physical and chemical traits of egg albumen from selected Polish breeding strains of laying hens
Tabela 3. Korelacje między wybranymi cechami fizykochemicznymi białka jaj pochodzącymi od polskich wybranych rodów hodowlanych kur nieśnych

Cechy	Ród							
	S-55	K-44	K-66	A-88	A-22	M-55	V-44	Całość/ Total
Masa białka/Albumen weight x procentowy udział białka w jaju/ % of albumen	0.862*	0.620*	0.791*	0.706*	0.692*	0.602*	0.773*	0.714*
wysokość białka/albumen height	0.303*	0.164	0.354*	0.363*	0.184	0.196	0.218*	0.257*
liczba Haugha/Haugh units	0.263*	0.019	0.213*	0.290*	0.106	0.073	0.168	0.156*
Procentowy udział białka w jaju/% of albumen x								
wysokość białka/albumen height	0.263*	0.206*	0.296*	0.243*	0.103	0.160	0.168	0.201*
liczba Haugha/Haugh units	0.283*	0.213*	0.238*	0.280*	0.098	0.164	0.169	0.208*
Odczyn pH białka/Albumen pH x								
zawartość białka og. w białku jaja/crude protein in the albumen	0.033	0.242	0.113	0.228	-0.050	0.071	0.273*	0.131*
stężenie lizozymu/lysozyme concentration	-0.154	-0.212	-0.116	-0.307*	-0.253	-0.043	-0.080	-0.140*
aktywność lizozymu/lysozyme activity	-0.153	-0.212	-0.118	-0.333*	-0.235	-0.044	-0.079	-0.140*
Zawartość białka og. w białku jaja/crude protein in the albumen x								
zawartość popiołu w białku jaja/% of ash in the albumen	-0.063	0.360*	0.238	0.233	0.145	-0.127	0.044	0.102*
zawartość wody w białku jaja/% of water in the albumen	-0.905*	-0.973*	-0.978*	-0.982*	-0.918*	-0.680*	-0.018	-0.452*
stężenie lizozymu/lysozyme concentration	-0.151	0.162	-0.069	-0.290*	-0.173	-0.164	-0.011	-0.101*
aktywność lizozymu/ lysozyme activity	-0.152	0.161	-0.067	-0.266	-0.190	-0.163	-0.010	-0.099*

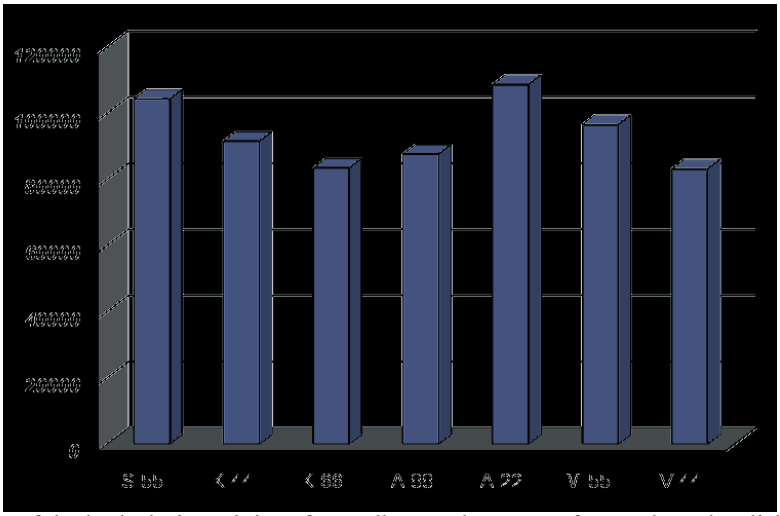

Figure 2. Comparison of the hydrolytic activity of egg albumen lysozyme from selected Polish breeding strains of laying hens
Wykres 2. Porównanie aktywności hydrolitycznej lizozymu białka jaj od wybranych polskich rodów hodowlanych kur nieśnych

CONCLUSIONS

The detailed quality investigation of the eggs from seven Polish breeding strains of layers (S-55, K-44, K-66, A-88, A-22, V-44 and M-55) and the calculated correlations among several physicochemical traits of egg albumen demonstrated statistically significant differences ($p \leq 0.05$) being affected by bird genotype.

Eggs from M-55 strain, due to favorable traits of albumen, e.g. highest percentage content in the egg, high weight, greatest albumen height and Haugh unit can be utilized in the development of commercial hybrids for large scale production of table eggs, among others, for processing purposes.

Egg albumen from the A-22 bird strain demonstrated the most desirable traits of lysozyme (high concentration and activity), therefore, that strain can be used in the formation of hybrids which probably will produce eggs of higher quantity of lysozyme to be used in the food industry, veterinary medicine and pharmacology.

The results of this study have been distributed among laying hen breeders throughout Poland. The results will help them to take appropriate decisions of lower risk pertaining to the trend and selection pressure in breeding flocks and in improving the required quality traits of eggs.

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Explanations:

x – mean value for the experimental group / średnia

n – number of birds in the group / liczba ptaków w grupie

s – standard deviation / odchylenie standardowe

v – variation coefficient, (%) / współczynnik zmienności

SEM – standard error mean

^{ab} – means statistically significant difference at $p \leq 0.05$ / średnie w wierszach oznaczone różnymi literami $^{a, b, c, d}$ różnią się istotnie dla $p \leq 0.05$

* - statistically significant difference at $p \leq 0.05$/ *- korelacja istotna statystycznie ($p \leq 0.05$)