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EFFECT OF LENGTH OF PRODUCTIVE LIFE OF RHODE ISLAND RED (R-11) HENS ON THEIR PERFORMANCE AND EGG QUALITY

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Abstract. The aim of the study was to evaluate production and egg quality results of Rhode Island Red (line R-11) hens during the first and second year of production. The study was performed with 200 Rhode Island Red hens and 210 eggs obtained at 21, 33, 43, 56, 73, 83 and 93 weeks of age. The results show that during rearing and egg production, birds were characterized by a high survival rate and good health. Laying rate averaged 64.18% during the first year of egg production (21 to 56 weeks) and 51.44% during the second year (63 to 99 weeks of age). Average body weight of the birds and egg weight in the first year of the study were up to breed standard, with significantly higher values in the second year of productive life. Egg quality assessment showed the average weight of eggs increased with the age of hens from 44.90 (week 21) to 64.14 g (week 93). The increase in egg weight was paralleled by a significant increase in yolk and shell weight. Eggs were characterized by good parameters of albumen (albumen height, Haugh units) and shell quality. These traits deteriorated significantly towards the end of the second egg production period. The production results and the good quality of eggs for almost the entire period of the second laying cycle indicate that it is appropriate to use Rhode Island Red R-11 hens for two years.

Key words: laying hens, age, egg quality

INTRODUCTION

Poland has an invaluable collection of the conservation breeds/lines of hens, which produce eggs differing in morphological and qualitative characteristics [Cy-

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wa-Benko 2002, Krawczyk and Calik 2010, Calik 2011]. They constitute precious genetic resources that can be used in the future in the programmes for genetic improvement of the commercial flocks of hens, and now reflect sound breeding practices that have been applied by Polish breeders over centuries. A special position among them is occupied by line R-11 of the Rhode Island Red (RIR) breed, which has been included by FAO in the list of the world genetic resources that need to be conserved [World Watch List 2000]. The breed was created in the second half of the 19th century in the U.S. state of Rhode Island. This relatively uniform breed was developed by crossing different hen breeds with Asian birds such as Cochins and Malay Bantams and through selection for increased egg production [Verhoef and Rijs 2003]. Before being recognized as a breed in the country of origin, the birds reached the European continent, where they became very popular as a utility breed. The R-11 line was imported into Poland from Great Britain before 1939 [Calik et al. 2012]. As a dual-purpose type, by the mid-1970s it accounted for 50% of the population of commercial farms and backyard flocks. The breed is especially suitable for backyard farming on free range. The cockerels, reared in hen houses with free-range access, weigh between 1300 and 1800 g at 12–13 weeks of age, and are characterized by yellow skin and good dressing percentage [Połtowicz et al. 2004]. Due to its genetically determined resistance to Marek's disease, the breed is characterized by a high survival rate (around 90%) in backyard rearing.

Information on the breed standard of the R-11 population, the numbers of males and females, and performance records are provided on the website of the National Research Institute of Animal Production [www.bioroznorodnosc.izoo.krakow.pl/drob].

Due to the increasing costs of rearing resulting from increasing prices of chicks, feeds and energy carriers, keeping layers for one season may be unprofitable and it might be appropriate to prolong their use for the next two or more production periods [Bernacki et al. 1999, Sokołowicz and Krawczyk 2004]. However, because most analyses performed on the farms of hens enrolled in the genetic resources conservation concern the first year of production (up to about 56 weeks of age), it is important to present the productivity and egg quality results for the extended production cycle.

The aim of the study was to evaluate production and egg quality results of Rhode Island Red hens of line R-11 during the first and second year of production.

MATERIAL AND METHODS

The experiment used 200 commercial Rhode Island Red hens of line R-11 and 210 eggs obtained during the laying period. R-11 hens were initially kept at the farm in Życzyn (PGO Podzamcze) and then at the Experimental Station of the National Research Institute of Animal Production in Chorzelów near Mielec. R-11 hens were evaluated in two egg production periods, from 21 to 56 weeks, and from 62 to 99 weeks. Birds were kept under good environmental conditions (temperature of 18–20°C and relative humidity of about 75%) on litter at a stocking density of 5 birds/m^2. During the first and second production period, they were fed the same commercial layer diet. Throughout the rearing and egg production periods, birds had unrestricted access to feed and water. Basic nutrients in the diet were analysed at the Central Laboratory of the National Research Institute of Animal Production. The diet contained 89.11% d.m., 2750 kcal $\cdot$ kg^{-1} ME, 16.93% crude protein, 2.15% crude fat, 2.54% crude fibre, 3.52% calcium and 0.53% total phosphorus, which conforms with the nutritional recommendations for laying hens [Smulikowska 2005].

A photoperiod of 6–8 h light was used when preparing the birds for the second egg production period (57 to 61 weeks). Birds were provided with maize grain and free access to water. The evaluation performed in the first and second production period accounted for the number of dead birds (%) and the cause of death, laying rate (%), and feed consumption per day/layer and per egg (g). Control weighing of hens (g) was performed at 21, 56 and 98 weeks of age by individually weighing the hens on a WPT/F 6C Radwag balance, accurate to 2 g.

Thirty eggs each were randomly selected at 21, 33, 43, 56, 73, 83 and 93 weeks of age, and after 24 h of cold storage at 4°C and 55% humidity, they were evaluated for quality using the EQM system (Egg Quality Measurements, TSS QCS-II). The evaluation included the following parameters: egg weight (g), shell colour (%), height of thick albumen (mm), Haugh units, yolk colour (pts.), shell weight (g), thickness (µm) and density (mg $\cdot$ cm^{-2}). Egg shape index was expressed as the ratio of the short border relative to the long border, measured with an electronic caliper, and shell strength (N) was measured with an Egg Crusher.

Chemical analyses of the eggs were performed at 33 and 83 weeks of age at the Central Laboratory of the National Research Institute of Animal Production to determine (%) dry matter, total protein and crude ash content of egg albumen, and percentage of dry matter, total protein, crude ash and crude fat in egg yolk. Cholesterol content of egg yolk (mg $\cdot$ g^{-1}) was determined by the Washburn and Nix method [cited after Cywa-Benko 2002], using an EPOLL 20 device at a wavelength of 500 nm.

The results were analysed statistically by analysis of variance and Duncan's test using Statgraphics Plus 5.1 package.

RESULTS AND DISCUSSION

In the flocks of hens conserved for biodiversity, pairs for mating are selected randomly with the rotation of cocks. In addition, no selection is carried out and all changes in the values of analysed traits result from the genetic properties of a given population and from the environmental conditions of the birds [Calik et al. 2012].

Table 1. Production results of Rhode Island Red R-11 hens

Tabela 1. Wyniki produkcyjne kur Rhode Island Red z rodu R-11

Item Wyszczególnienie	Week of age Tydzień życia	Mortality and health-related culling Padnięcia i brakowania zdrowotne, %	Feed consumption, g/bird Zużycie paszy, g/osob.	Feed consumption, g/egg Zużycie paszy, g/jajo	Laying Nieśność, %
1st production period I okres produkcji	21–24	–	105	320	36.18
	25–28	–	107	157	74.69
	29–32	–	108	169	69.96
	33–36	–	107	201	59.61
	37–40	0.50	110	177	68.78
	41–44	–	109	172	69.96
	45–48	–	112	177	69.60
	49–52	–	112	187	65.84
	53–56	–	113	197	63.00
Sum/Average – Suma/Średnia		0.50	109	195	64.18
2nd production period II okres produkcji	62–65	–	117	313	41.45
	66–69	–	118	213	58.11
	70–73	1.01	115	223	56.61
	74–77	–	118	216	56.12
	78–81	–	116	239	53.03
	82–85	1.02	118	228	55.65
	86–89	–	118	253	50.20
	90–93	0.51	118	241	52.03
	94–97	0.52	118	261	46.05
	98–99	–	118	257	45.15
Sum/Average – Suma/Średnia		3.05	118	244	51.44

As is clear from Table 1, the health of hens was good in both the first and second production period. The most frequent causes of mortality and health-related culling (especially towards the end of the second production period) were mechanical injuries and single cases of liver degeneration. Analysis of the data for 2003-2008 (rearing period and first year of production) also showed that the R-11 flock kept at the Experimental Station in Chorzelów was in good health [Krawczyk and Calik 2010]. A study by Cywa-Benko [2002] demonstrates that in the 1990s this population suffered from high mortality in excess of 20%, but the farm in Życzyn was being closed down during that time and there were inadequate financial resources for prophylaxis and proper feeding. Moving the birds to the Experimental Station in Chorzelów and considerable improvements in environmental conditions caused the health of the flock to improve significantly. In a study by Sokołowicz and Krawczyk [2005] with a flock of Hy-Line Brown hens, mortality and culling levels were 5.7% in the first egg production period and averaged 8.3% in the second year of production. Bernacki et al. [1999] reported similar values of this trait for A-83 and Astra S hens as well as a significantly higher percentage of deaths and health-related culling in a flock of Tetra SL and A-83 hens (13.3 and 16.7%, respectively), which increased after 118 weeks of age and were mostly related to pathological changes in the liver.

The average body weight (Fig. 1) of the hens was 1896 and 2094 g at 21 and 56 weeks of age, respectively, and 2330 g at 98 weeks. Daily feed consumption per layer and per egg during the first production period (109 and 195 g) was lower than in the second (118 and 244 g, respectively). Average egg production was 64.18% in the first year of production and 51.44% in the second (Table 1). These results agree with the findings of other authors, who report that hen laying rate in the second period of production is about 10–20% lower than in the first year of production, which is compensated by greater egg weight [Bernacki and Mazanowski 1997, Adamski et al. 2004, Sokołowicz and Krawczyk 2005].

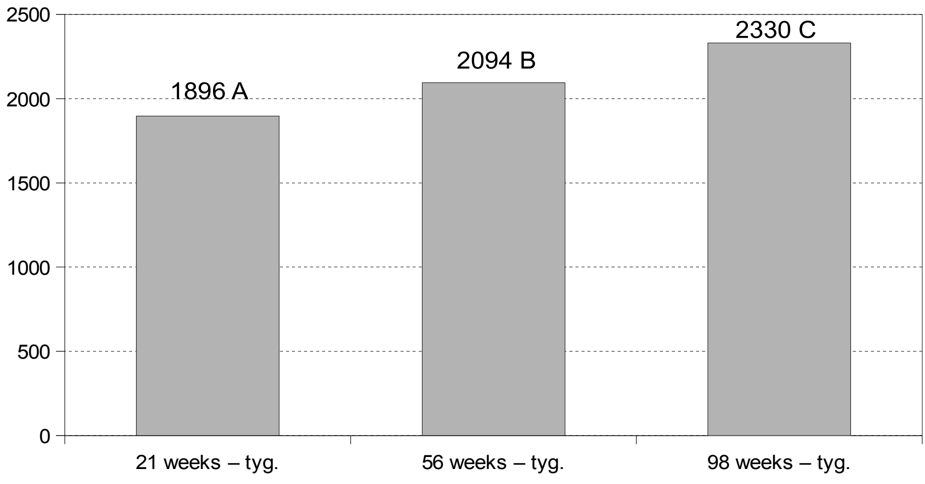

Fig. 1. Body weight (g); values with different letters, A, B, or C, differ significantly ($P < 0.01$)

Rys. 1. Masa ciała (g); wartości oznaczone różnymi literami, A, B, or C, różnią się istotnie ($P < 0,01$)

The measurements of morphological characteristics of eggs from R-11 hens are shown in Table 2. During the observations, average egg weight increased from 44.90 (week 21) to 64.14 g (week 93), with the highest growth dynamics observed between 20 and 33 weeks of age. The significant increase in egg weight was pa-

Table 2. Results of qualitative evaluation of eggs from Rhode Island Red R-11 hens

Tabela 2. Wyniki oceny jakości jaj Rhode Island Red z rodu R-11

Item Wyszczególnienie		Week/Tydzień						
		21.	33.	43.	56.	73.	83.	93.
Egg weight Masa jaja, g	$\bar{x}$	44.90 A	52.53 B	57.43 C	59.42 CD	60.99 DE	61.84 DE	64.14 E
	SD	3.06	3.68	3.26	2.89	2.88	3.60	4.53
	cv	6.81	7.01	5.67	4.86	4.72	5.82	7.28
Yolk weight Masa żółtka, g	$\bar{x}$	11.89 A	14.56 B	16.92 C	17.82 D	18.50 DE	19.07 DE	19.56 E
	SD	1.09	1.13	1.05	1.44	1.15	1.29	1.34
	cv	9.16	7.76	6.21	8.08	6.23	6.83	7.10
Shell weight Masa skorupy, g	$\bar{x}$	4.44 A	5.37 Ba	5.71 BCb	5.79 C	5.83 C	5.93 C	6.09 Cc
	SD	0.41	0.51	0.57	0.70	0.43	0.60	0.71
	cv	9.16	9.50	10.04	12.14	7.39	10.06	11.55
Shell colour Barwa skorupy, %	$\bar{x}$	38.87 A	46.07 BCa	45.56 BC	49.46 C	41.93 AB	45.13 BCb	44.79 BC
	SD	4.52	6.50	5.43	5.78	5.13	6.02	5.86
	cv	11.63	14.11	11.93	11.68	12.23	13.34	13.08
Shape index Indeks kształtu, %	$\bar{x}$	77.98 A	77.04 ABa	75.56 BC	75.77 BC	75.15 BCb	74.87 C	74.42 C
	SD	2.20	3.03	2.88	2.76	2.39	2.58	2.97
	cv	2.82	3.94	3.82	3.65	3.18	3.44	3.99
Albumen height Wysokość białka, mm	$\bar{x}$	8.35 Aa	8.14 ABa	7.10 CDb	7.54 BCb	6.52 Dc	7.22 CDb	6.51 Dc
	SD	1.10	1.07	1.05	0.98	0.81	0.99	0.64
	cv	13.25	13.21	14.78	13.03	12.42	13.81	9.83
Haugh units Jednostki Haugha, JH/HU	$\bar{x}$	95.28 A	92.34 A	84.39 B	86.54 B	79.17 C	84.72 B	78.92 C
	SD	5.16	5.76	6.71	5.60	7.14	6.06	7.57
	cv	5.41	6.24	7.96	6.47	9.03	7.16	9.59
Yolk colour, pts Barwa żółtka, pkt.	$\bar{x}$	7.03	6.70 a	6.92	7.17	7.32	7.43	7.76 b
	SD	0.66	0.75	0.75	0.48	0.88	0.90	0.75
	cv	9.38	11.19	10.98	6.71	12.02	12.11	9.79
Shell thickness Grubość skorupy, µm	$\bar{x}$	348 Aa	328	329	325 b	336	324 b	315 B
	SD	18.60	29.52	31.53	35.32	35.03	40.89	41.58
	cv	5.54	9.01	9.58	10.88	10.06	12.62	13.20
Shell density Gęstość skorupy, mg · cm^{-2}	$\bar{x}$	76.84 a	74.78	76.42 a	72.80	74.23	72.85	72.16 b
	SD	5.44	8.16	6.37	7.62	7.76	7.26	7.87
	cv	7.12	10.91	8.30	10.47	10.46	10.07	10.81
Shell strength Wytrzymałość skorupy, N	$\bar{x}$	33.65 a	33.22 a	30.67	29.60 b	29.55	28.54	26.83 b
	SD	9.67	7.05	6.95	8.28	7.95	8.20	7.27
	cv	28.74	21.25	22.66	27.97	26.89	28.73	27.10

A, B… – values in rows with different letters differ significantly ($P < 0.01$); a, b… at $P < 0.05$.
A, B… – wartości w wierszach oznaczone różnymi literami różnią się istotnie ($P < 0,01$); a, b… dla $P < 0,05$.

ralleled by a highly significant increase in shell weight (from 4.44 to 6.09 g) and yolk weight (from 11.89 to 19.56 g) between 21 and 93 weeks of age. The significant increase in egg weight with the age of the hens is consistent with the results obtained by other authors [Premavilli et al. 2004, Basmacioglu et al. 2005, Calik 2011]. In general, egg weight is positively correlated to body weight, and Hocking et al. [2003] report these traits to be characterized by a high coefficient of heritability (h2 > 0.5). The same authors also stress that egg laying rate is an important determinant of egg weight. As the eggs increased in size with the age of the layers, eggs became more elongated, as evidenced by a decrease in shape index from 77.98 to 74.42%. Similar relationships were noted by Hunton [2005] and Rizzi and Marangon [2012], who showed this trait to be dependent also on hen genotype and to be important in marketing because it influences the breaking strength of eggs. Shell colour is the trait most correlated with hen genotype [Pavlovski et al. 2004, Roberts 2004] and its intensity depends on age. In the present study, shell colour intensity of eggs from 21-week-old hens was 38.87%, and changed at the next evaluations from 41.93 (week 73) to 49.46% (week 56). Hunton [2005] reports that dark shell colour is dependent on heminic pigments, with shell colour intensity being inversely proportional to egg production, which was also observed in the present study.

The egg albumen quality parameters (albumen height and Haugh units) evaluated between 21 and 93 weeks decreased from 8.35 to 6.51 mm and from 92.58 to 78.92, respectively. The deterioration in the quality of albumen from eggs obtained from older hens is supported by the studies of Bernacki et al. [1999], Silversides and Budgell [2004] and Lewko and Gornowicz [2009]. Adamski et al. [2004] also showed the height of thick albumen to decrease in the egg production period in Tetra SL hens, which is indicative of the loss of the gel structure. The same authors failed to observe such a relationship in Hy-Line hens, because the height of albumen from the eggs evaluated between 89 and 114 weeks of age increased. According to Campo et al. [2000] egg albumen quality should exceed 60 Haugh units, which allows a conclusion that R-11 hen eggs laid towards the end of the second egg production period were characterized by good albumen quality.

Yolk colour intensity changed from 7.03 (week 21) to 7.76 pts (week 93) on the Roche scale. As reported by Nys [2000], yolk colour intensity is affected by the hen's laying rate and the artificial or natural xanthophylls present in feed. Zeaxanthin and lutein (pigments found in dried forage and maize grain) are deposited in egg yolks at 12–20% of their feed content, and synthetic pigments at 40–50%. The present study showed that the yolks of eggs from older hens were characterized by more intense colour, which was probably due to the lower laying rate and longer consumption of feed supplemented with pigments. Greater yolk colour intensity in the second egg production period was also reported in Tetra SL and Hy-Line hens by Adamski et al. [2004], who concluded that the more intense yolk colour of eggs from hens fed a uniform diet in terms of the pigment content throughout the production period, shows that the hens were not exhausted from laying eggs.

Table 3. Chemical analysis of albumen from eggs of Rhode Island Red R-11 hens

Tabela 3. Analiza chemiczna białka jaj kur Rhode Island Red z rodu R-11

Item Wyróżnienie		Week – Tydzień	
		33	83
Dry matter Sucha masa, %	$\bar{x}$	13.61A	11.94 B
	SD	0.82	0.46
	cv	5.99	3.89
Crude ash Popiół surowy, %	$\bar{x}$	0.67	0.65
	SD	0.03	0.03
	cv	4.55	4.61
Total protein Białko ogólne, %	$\bar{x}$	11.61A	10.22B
	SD	0.67	0.46
	cv	5.77	4.53

Explanatory notes as in Table 2.
Objaśnienia jak w tabeli 2.

Table 4. Chemical analysis of yolk from eggs of Rhode Island Red R-11 hens

Tabela 4. Analiza chemiczna żółtka jaj kur Rhode Island Red z rodu R-11

Item Wyróżnienie		Week – Tydzień	
		33	83
Dry matter Sucha masa, %	$\bar{x}$	49.88	51.51
	SD	1.53	0.89
	cv	3.06	1.74
Crude ash Popiół surowy, %	$\bar{x}$	1.54	1.58
	SD	0.02	0.10
	cv	1.44	6.64
Total protein Białko ogólne, %	$\bar{x}$	16.09	16.24
	SD	0.26	0.32
	cv	1.62	1.97
Crude fat Tłuszcz surowy, %	$\bar{x}$	32.59	33.93
	SD	0.93	1.76
	cv	2.85	5.18
Cholesterol content Zawartość cholesterolu, $mg \cdot g^{-1}$	$\bar{x}$	14.78	14.93
	SD	0.51	0.65
	cv	3.45	4.41

The results of Nys et al. [2001] and Premavalli and Viswanagthan [2004] indicate that egg shell quality, mainly shell strength, thickness and density deteriorate significantly with layer age. In the present study, the highest strength was characteristic of the shells from eggs obtained from 21-week-old hens (33.65 N), which also exhibited highest shell density (76.84 mg · cm^{-2}) and thickness (348 µm). On subsequent evaluation dates, shell quality parameters were found to gradually deteriorate, and the lowest breaking strength was characteristic of shells from eggs laid by 93-week-old hens (26.83 N), which were also characterized by the lowest shell density (72.16 mg · cm^{-2}) and thickness (315 µm). The present results support the statement that egg shell strength decreases with the age of the hens, which is probably related to a deterioration in calcium and phosphorus absorption and a slowing of the shell mineralization process as the hens grow older [Roberts 2004, Rizzi and Marangon 2012].

The results obtained for the chemical properties of egg albumen and yolk are presented in Tables 3 and 4. Dry matter content of egg albumen at 33 and 83 weeks was 13.61 and 11.94%, respectively, and the difference was statistically significant. The albumen of eggs evaluated at 33 weeks of age had a higher content of total protein (11.61%) and crude ash (0.67%). Compared to the findings of Lewko and Gornowicz [2009], who investigated seven domestic lines of laying hens (S-66, K-44, K-66, A-22, A-88, M-55 and V-44), the albumen of eggs from R-11 hens was characterized by a greater content of total protein and a comparable content of water. In yolks, dry matter content averaged 49.88% or 51.51%, and crude ash content averaged 1.54% or 1.58%. A higher content of total protein (16.24%) and fat (33.93%), unconfirmed statistically, was observed in yolks of eggs from 83-week-old hens compared to eggs from 33-week-old hens (16.09% vs. 32.59%). The higher fat content of eggs from older birds indicates that they are more suitable for processing because of improved emulsifying capacity, which is useful for production of confectionery coatings and pasta. The overall concentration of cholesterol in 1 g of yolk at 33 and 83 weeks of hen age was similar at 14.78 and 14.93 mg, respectively. Cywa-Benko [2002] holds that yolk cholesterol concentration increases with the age of the hens as a result of a decline in egg production. Zgłobica et al. [1995] also showed in commercial layer hybrids that this trait is inversely proportional to the laying rate. A study by Czaja and Gornowicz [2006] with commercial hens (Rosa 1, Rosa 2, Messa 443, Messa 445, Astra D, Astra N, Astra W, Astra W-2) and experimental hens (N-11$\times$P-11) showed that changes in chemical composition of eggs (mainly total protein content of eggs from older hens) were associated with hen age to a greater extent than with the hen genome.

CONCLUSIONS

1. It is concluded from the results obtained that extending the productive life of R-11 hens to the second production cycle has no adverse effect on survival and health of the birds.
2. The average body weight of the birds and egg weight in the second year of production were significantly higher than in the first year.
3. Based on physicochemical analyses, it was found that eggs laid by R-11 hens in the first and second year of production were characterized by good quality parameters.
4. The good productivity of R-11 hens and good egg quality in the second year of production indicate that it is justified to use the birds for two years.

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WPŁYW CZASU UŻYTKOWANIA KUR RHODE ISLAND RED (R-11) NA ICH WYNIKI PRODUKCYJNE I JAKOŚĆ JAJ

Streszczenie. Celem przeprowadzonych badań była ocena wyników produkcyjnych i jakości jaj kur rasy Rhode Island Red z rodu R-11, znanych też pod nazwą Karmazyn w pierwszym i drugim roku ich użytkowania. Badania przeprowadzono na 200 kurach rasy RIR i 210 jajach pozyskanych w 21., 33., 43., 56., 73., 83. i 93. tygodniu ich życia. Wyniki badań wskazują na dużą przeżywalność i dobre zdrowie ptaków w czasie wychowu i produkcji jaj. W pierwszym roku użytkowania nieśnego tj. od 21. do 56. tygodnia średnia nieśność wynosiła 64,18%, natomiast w drugim tj. od 63. do 99. tygodnia życia 51,44%. Średnia masa ciała ptaków i masa jaja w pierwszym roku oceny nie odbiegała od ustalonych standardów rasowych, przy istotnie wyższych wartościach w drugim roku ich użytkowania. Na podstawie uzyskanych wyników oceny jakości jaj można stwierdzić, że średnia masa jaja zwiększyła się z 44,90 (21. tydz.) do 64,14 g (93 tydz.) wraz z wiekiem kur. Wzrostowi masy jaja towarzyszył istotny wzrost masy żółtka i skorupy. Jaja odznaczały się dobrymi parametrami jakości białka (wysokość białka i jednostek Haugha) i skorupy. Istotne pogorszenie wartości tych cech odnotowano dopiero pod koniec drugiego okresu nieśności. Wyniki produkcyjne i dobra jakość jaj przez prawie cały drugi cykl nieśności wskazuje na zasadność użytkowania kur Rhode Island Red z rodu R-11, do dwóch lat.

Słowa kluczowe: kury nieśne, wiek, jakość jaja

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