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Changes in the Biological Value of Duck Eggs Defined by Egg Quality

Marek ADAMSKI, Zenon BERNACKI and Joanna KUŹNIACKA

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The aim of the present paper was to evaluate the biological value of duck eggs based on the morphological composition and physical traits during lay. Eggs were tested, with 3-week intervals, up to the 22^{nd} lay week. It was demonstrated that over lay, the egg weight and surface area, shell thickness and density as well as the number of pores throughout the shell surface increased. The egg contents analysis showed that during lay the weight and percentage share of yolk and thin albumen increased, while a decrease was found in the weight and share of thick albumen and the density of yolk and both fractions of albumen as well as the height of thick albumen and Haugh unit score, which can deteriorate the biological value of eggs.

Key words: Duck, egg, yolk, albumen, shell.

Marek ADAMSKI, Zenon BERNACKI, Joanna KUŹNIACKA, Department of Poultry Breeding, Faculty of Animal Sciences, University of Technology and Agriculture, Mazowiecka 28, Bydgoszcz, Poland
E-mail: adamski@atr.bydgoszcz.pl

Physical traits of the egg and the value of respective characters serve a basic biological function of the egg, which is the capacity for embryo development in specific environmental conditions (TRZISZKA 2000). So far duck egg studies (ADAMSKI 2005; GÓRSKI *et al*. 1998; KSIĄŻKIEWICZ & BEDNARCZYK 1996) have aimed at evaluating the egg structure and its characteristic layer pattern.

In those parts of the world where duck eggs are used for consumption, foreign literature offers reports in which the authors refer to egg quality characters as functional and important. The effect of duck age on egg quality was dealt with by YANNAKOPOULOS and TSERVENI-GONSI (1987). DAVIS *et al*. (1993) investigated the effect of temperature and season on the quality of duck eggs, while MINH *et al*. (2000) determined qualitative characters of Khaki Campbell and Co Bau duck eggs, and also developed a method of duck egg storage for human consumption during which the egg quality deteriorates only slightly.

Duck egg quality studies covered such external characters as width and length, egg shape index and non-destructive shell deformation and the characters of egg contents, e.g. the share of yolk and albumen in the egg weight, thick albumen height and Haugh unit score, defining the egg freshness. The effect of external egg characters on the development of ducklings hatched was reported by KSIĄŻKIEWICZ *et al*. (1998), whereas other reports (GÓRSKI *et al.* 1998; KSIĄŻKIEWICZ & BEDNARCZYK 1996) indicated the effect of lay hen age KSIĄŻKIEWICZ origin on the quality of duck eggs and the effect of egg quality on the duckling hatch results.

Information was found in the available literature on the qualitative characters of duck eggs at the beginning, at the peak production and at the end of lay (ADAMSKI 2005; GÓRSKI *et al* 1998; MAZANOWSKI & ADAMSKI 2002). In this study a thorough analysis of changes in the morphological composition (percentage share of yolk, albumen and shell) and physical characters of duck eggs during the first lay was undertaken, facilitating the evaluation of their biological value. The aim of the present paper was to evaluate the morphological composition and physical traits of eggs to the 22^{nd} week of Peking duck lay.

Material and Methods

The duck egg quality analysis was made in 2002 at the Department of Poultry Breeding, the University of Technology and Agriculture in Bydgoszcz, Poland. A55 strain duck eggs were provided by the Waterfowl Breeding Farm at Dworzyska. The eggs were investigated at 3-week intervals from the beginning to the 22nd week of the first duck lay. A total of 180 eggs were evaluated 24 hours after being laid. The egg weight (g) was recorded using RADWAG WPS 360 C scales. The egg width to length ratio was the egg index (%). To calculate the egg surface area (cm^2), the following formula was applied (PAGANELLI *et al*. 1974):

$$P_S = 4.835 \text{ x } W^{0.662}; \text{ in which } W = \text{egg weight.}$$

Non-destructive deformation of the shell (μm) was determined using the Marius tester. With the QCD apparatus by TSS, a British manufacturer, the thick albumen height and yolk (mm) were measured. An index was calculated based on the yolk dimensions. The yolk colour was evaluated with a 15-point La Roche scale. Similarly the blood/meat spot incidence in eggs was determined. The thick albumen height (H) and egg weight (W) were used to calculate the Haugh unit score using the following formula (WILLIAMS 1992):

$$JH = 100 \lg (H + 7.7 - 1.7 W^{0.37})$$

Two albumen fractions, thick and thin, were separated from the egg contents with the pipette Yolk, and then thick albumen were weighed using WPS 360 C scales. A CP-401 pH-meter was applied to determine the pH of yolk, thick and thin albumen. Similarly the density of yolk and two albumen fractions (g/cm^3) were determined with the liquid density set, applying the WPS 360 C scales software. The egg shell weight was defined after 3-hour drying at a temperature of 105°C, and its thickness (mm) with an electronic micrometric screw. The shell thickness was investigated after separation of a 1 to 2 g sample with a solid density set, applying the WPS 360 C scales software. Also, the shell porosity was determined by a method described in earlier papers (ADAMSKI 2004; MAZANOWSKI & ADAMSKI 2003). The difference between the egg weight and the yolk weight, thick albumen and shell was used to calculate the thin albumen weight. The percentage content of yolk, thick and thin albumen and shell in the egg were also calculated.

The numerical data were verified with statistical analysis, calculating means for a given trait for respective examination dates. The egg structure and contents characters are given in the form of linear regression equations, used to determine linear trends for the characters following the formula given by ZAJĄC (1988):

$$y_t = a + b_t$$

where

a – trait value over the zero period,

b – regression coefficient expressing 3-week growth rate for a given character,

t – time expressed as the number of successive lay weeks.

Results

The shell traits and egg structure (Fig. 1) showed differences in their weight across the evaluation dates. The egg weight increased from 74 g at the beginning of lay to 95 g at the end. The linear regression equation calculated for the egg weight was significant. The average egg weight throughout lay was 89.6 g (Table 1). A significant increase in the egg width and length was also noted.

The greater the egg weight and dimensions, the greater the egg shell surface area, increasing up to 98.8 cm^2 (Fig. 2). During lay, the number of pores increased in different parts of the shell and throughout its surface area. The lowest number of pores was found at the pointy end of the egg from 11 to 19, more at the equatorial regions from 19 to 27, while the highest number – at the rounded end – from 25 to 37. Furthermore, the duck egg shell during lay showed a high increase in the number of pores throughout the surface area from 6124 in the first week to 11035 pores in the 19th lay week, which is confirmed by significant linear regression equation calculated for that character.

The increase in shell thickness from 0.338 to 0.381 mm coincided with a decrease in non-destructive egg shell deformation from 30.3 at the beginning to 25.9 μm at the end of lay. Linear regression equations used to determine the trend for thickness and non-destructive deformation of the shell were significant. The egg shell weight, which was the lowest at the beginning (7 g), was the highest (9 g) in the 19th production week. The egg shell weight trend increased significantly, while the trend of the share of the shell in the egg decreased (Fig. 2).

The shell thickness was the lowest at the beginning (1.928 g/cm^3), and the highest – at peak production (2.120 g/cm^3).

Analysing the egg contents traits (Fig. 3), it was shown that the duck lay coincided with an increase in the weight and percentage share of yolk in the egg weight. The lowest yolk weight was recorded

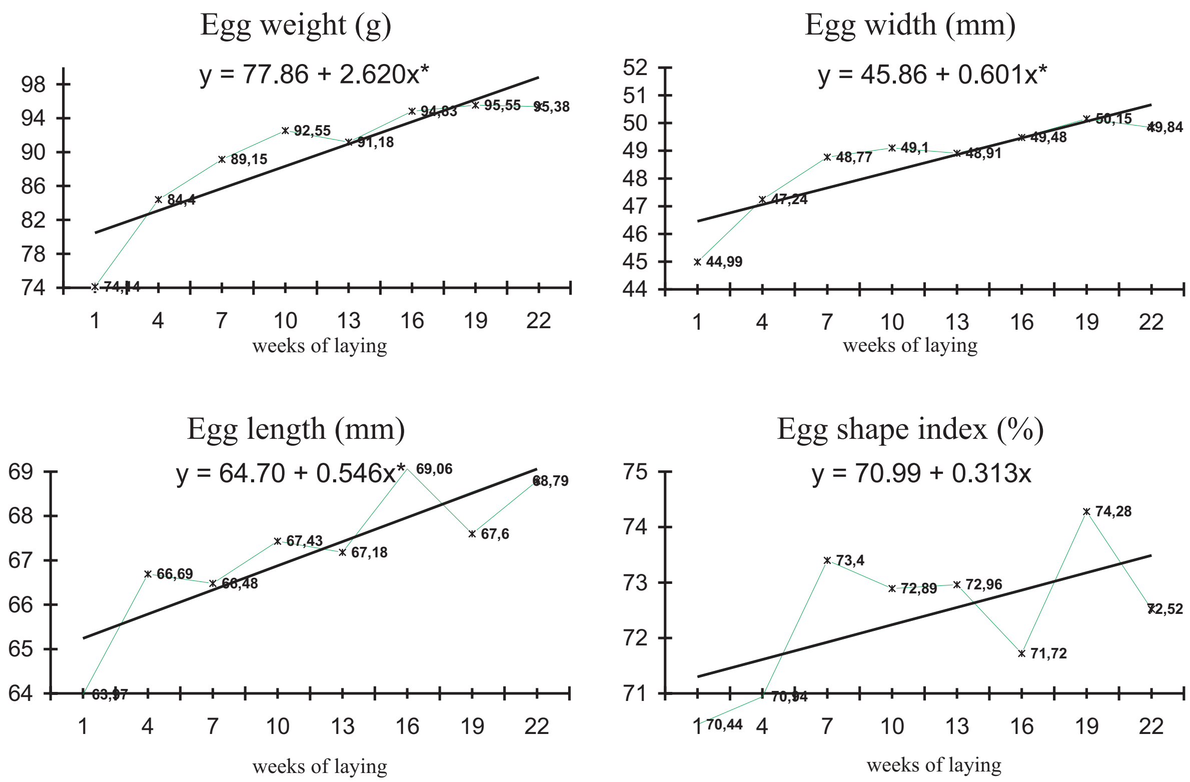

Fig. 1 Time trends of egg traits. * Statistically significant time trend (P≤0.05)

Table 1

Mean values (x) and variation coefficients (v) of duck egg traits

Trait	Statistical measures	
	x	v
Egg weight (g)	89.6	6.8
Egg width (mm)	48.6	2.6
Egg length (mm)	67.2	3.8
Egg shape index (%)	72.4	4.4
Egg area surface (cm^2)	94.7	4.5
Egg shell deformation (μm)	26.3	13.4
Egg shell thickness (mm)	0.360	6.6
Egg shell weight (g)	8.4	6.7
Egg shell proportion (%)	9.4	6.0
Egg shell density (g/cm^3)	2.002	3.5
Pores in the whole egg shell (units)	9004	6.5
Yolk weight (g)	28.3	10.3
Yolk proportion (%)	31.5	7.0
Yolk density (g/cm^3)	0.391	5.5
Yolk pH	5.63	1.1
Yolk colour (points)	5.1	16.2
Yolk dimeter (mm)	49.9	4.6
Yolk height (mm)	20.6	5.1
Yolk index (%)	41.3	5.9
Thick white weight (g)	23.3	14.9
Thin white weight (g)	29.6	11.8
Thick white proprotion (%)	26.3	13.7
Thin white proportion (%)	32.9	9.6
Thick white density (g/cm^3)	0.344	7.5
Thin white density (g/cm^3)	0.259	10.1
Thick white pH	8.78	1.4
Thin white pH	8.65	1.6
Thick white height (mm)	6.5	16.9
Haugh Units (HU)	69.8	13.7

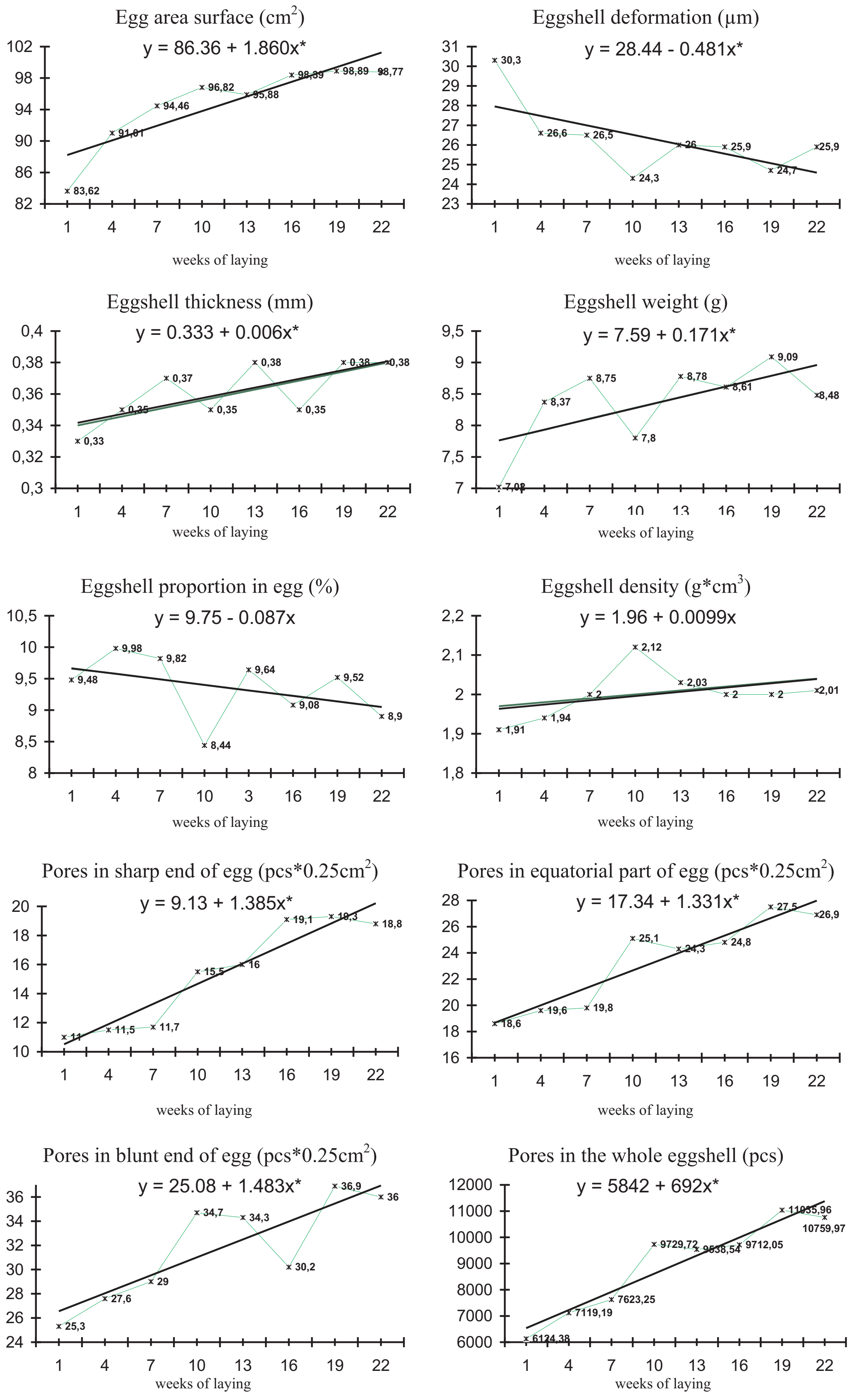

Fig. 2. Time trends of eggshell traits. * Statistically significant time trend ($P \leq 0.05$).

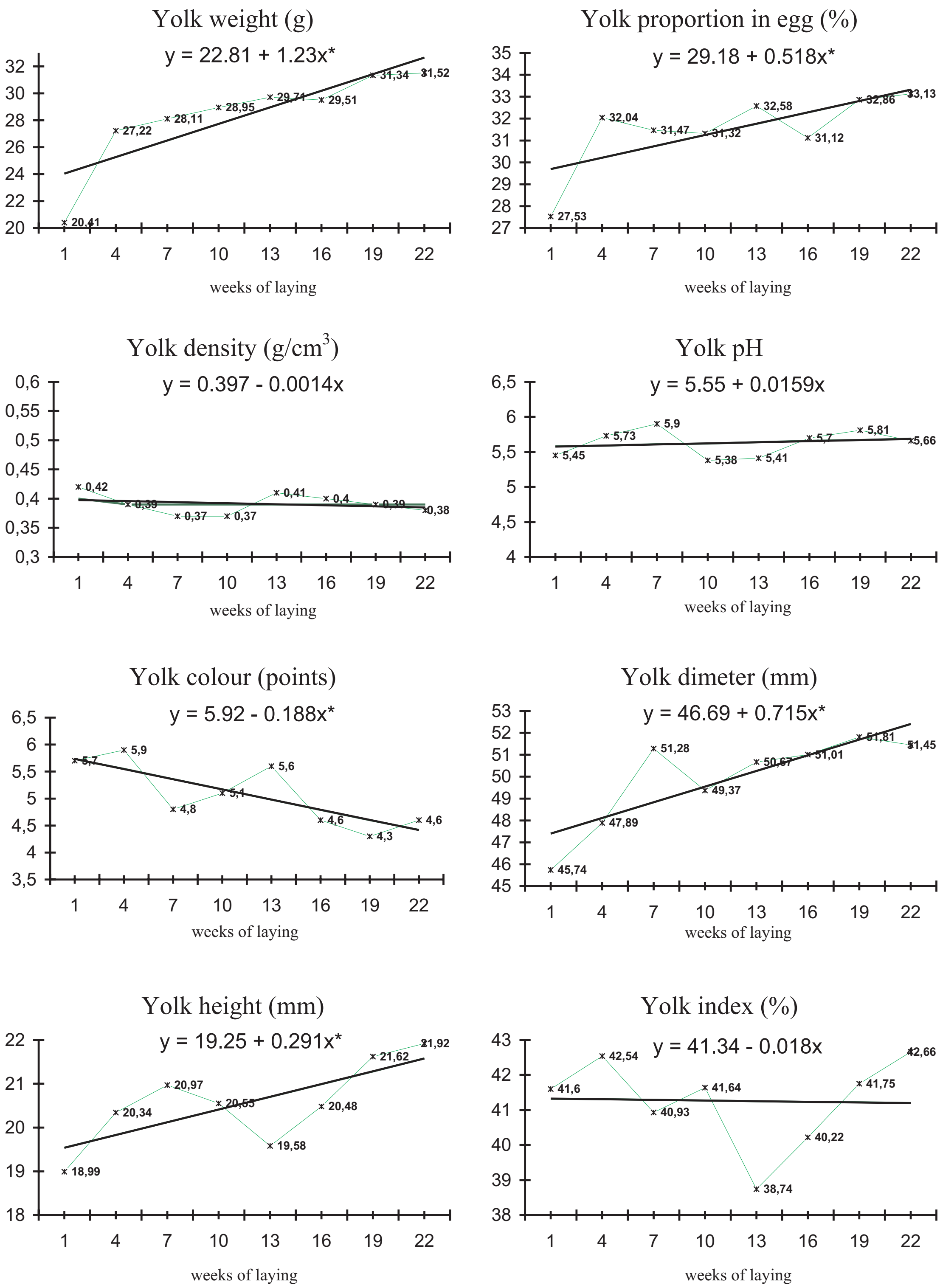

Fig. 3. Time trends of egg yolk traits . * Statistically significant time trend (P≤0.05).

at the beginning of lay (20.4 g), and the highest – at the end of lay (31.52 g). Trends of the percentage share and yolk weight in duck eggs increased, and the linear regression equations used to determine the trends were significant. The intensity of the yolk colour defined using the La Roche scale decreased over lay from 5.9 to 4.3 points, which is confirmed by a significantly decreasing trend for that character.

The yolk diameter and height showed a growing trend from the 1st to the 22nd week of duck lay, while the yolk index was similar, except for the 13th lay week. The yolk density was the highest at the beginning of lay (0.420 g/cm^2), and the lowest – at the end of lay (0.380 g/cm^2). Mean pH values for yolk throughout lay assumed similar values (Fig. 3).

The highest weight and percentage share of thick albumen in eggs were recorded in the first lay week (Fig. 4). The lower the weight and percentage share of thick albumen in eggs at the peak production and at the end of lay, the significantly higher weight and percentage share of thin albumen in eggs. A similar tendency was found for changes in the density of both egg albumen fractions where the lowest density of thick and thin albumen was recorded at the peak production and at the end of duck lay.

Duck eggs characterized the highest yolk density, a lower density of thick albumen and the lowest of thin albumen (Figs 3 and 4).

The pH values for thick albumen were higher than those recorded for thin albumen (Fig. 4). It was shown that pH values of both duck egg albumen fractions were the highest between the 7th and 16th lay week. The thick albumen height decreased over duck lay, which decreased the Haugh unit score.

Discussion

In the present research the egg weight increased from 74 to 95 g. A similar trend was reported investigating ducks of different origin (ADAMSKI 2005). A lower egg weight (87.1 and 87.2 g) in ducks of the same origin was reported by GÓRSKI *et al*. (1998) and in three maternal duck strains: P66, P77 and K11 (MAZANOWSKI and ADAMSKI 2002). Lower-weight eggs (from 85.2 to 86.2 g) were also laid by ducks of English origin A1, A2 and A3 and P8 (KĄŻKIEWICZ & BEDNARCZYK 1996), from which A55 strain was obtained.

Increasing dimensions of duck eggs in the present research significantly affected the changes in the egg shape index value. Duck egg dimensions reported by GÓRSKI *et al*. (1998) were 48.8 and 50.0 mm (width) and 66.4 and 65.6 mm (length) and were similar to the results reported in the present research. Slight differences in duck egg dimensions found in the present research and reported by other authors suggest that the egg width and length in ducks of the same origin were less affected by keeping and feeding conditions and more by the genotype. The egg length and width were greater than those found in English origin and P8 flock ducks, (KĄŻKIEWICZ *et al*. 1998, 1999), which could have been due to the egg weight increasing with years in ducks of the breed investigated (MAZANOWSKI *et al*. 1999).

In the present research it was shown that the greater the egg weight, the greater the shell surface area. A similar relationship was found in eggs of ducks of another origin (ADAMSKI 2005) and high-performance Astra G geese in which the egg surface area increased from 124.5 to 132.6 cm^2 (MAZANOWSKI & ADAMSKI 2002). Additionally the duck egg shell showed a large increase in porosity during lay, which must have been connected with an increasing egg surface area.

The greater the shell thickness, the lower the non-destructive egg shell deformation, up to 25.9 μm at the end of lay, which points to an increasing duck egg shell strength. The non-destructive deformation of egg shell in Peking ducks kept abroad (YANNAKOPOULOS & TSERVENI-GONSI 1987) was lower than reported in the present research as it ranged from 20.2 to 25.2 μm and increased over lay, similarly to that reported in other research (ADAMSKI 2004). Unlike in the ducks evaluated in the present research, MAZANOWSKI and ADAMSKI (2002) demonstrated that the shell thickness at the end of an intensive lay in geese decreased. Other authors (GÓRSKI *et al*. 1998) reported on the eggs of the A55 breed ducks showing a thicker shell (0.400 mm), similarly as in preservation groups ducks (KĄŻKIEWICZ & BEDNARCZYK 1996), used to breed this lineage.

In the present research the lowest shell weight was found at the beginning of lay. Changes in the shell weight over lay were related to the increase in its thickness and density. However, in spite of this, the trend of the percentage share of the shell in the egg decreased, which, in turn, was connected with a high increase in the egg and yolk weight.

The yolk weight was similar to that reported by GÓRSKI *et al*. (1998) for eggs of ducks of the same origin (30.1 g) and lower (30.7 to 31.7 g) than in the eggs of ducks (KĄŻKIEWICZ *et al*. 1999) representing A1, A2, A3 and P8 flocks (31.4 g). Trends of the percentage share and weight of yolk in the present experiment increased, while the linear regression equations used to determine the trends were significant. Similarly, the share of yolk in goose eggs over lay increased from 30.1 to 37.9% and was the highest at the end of lay (MAZANOWSKI & ADAMSKI 2002).

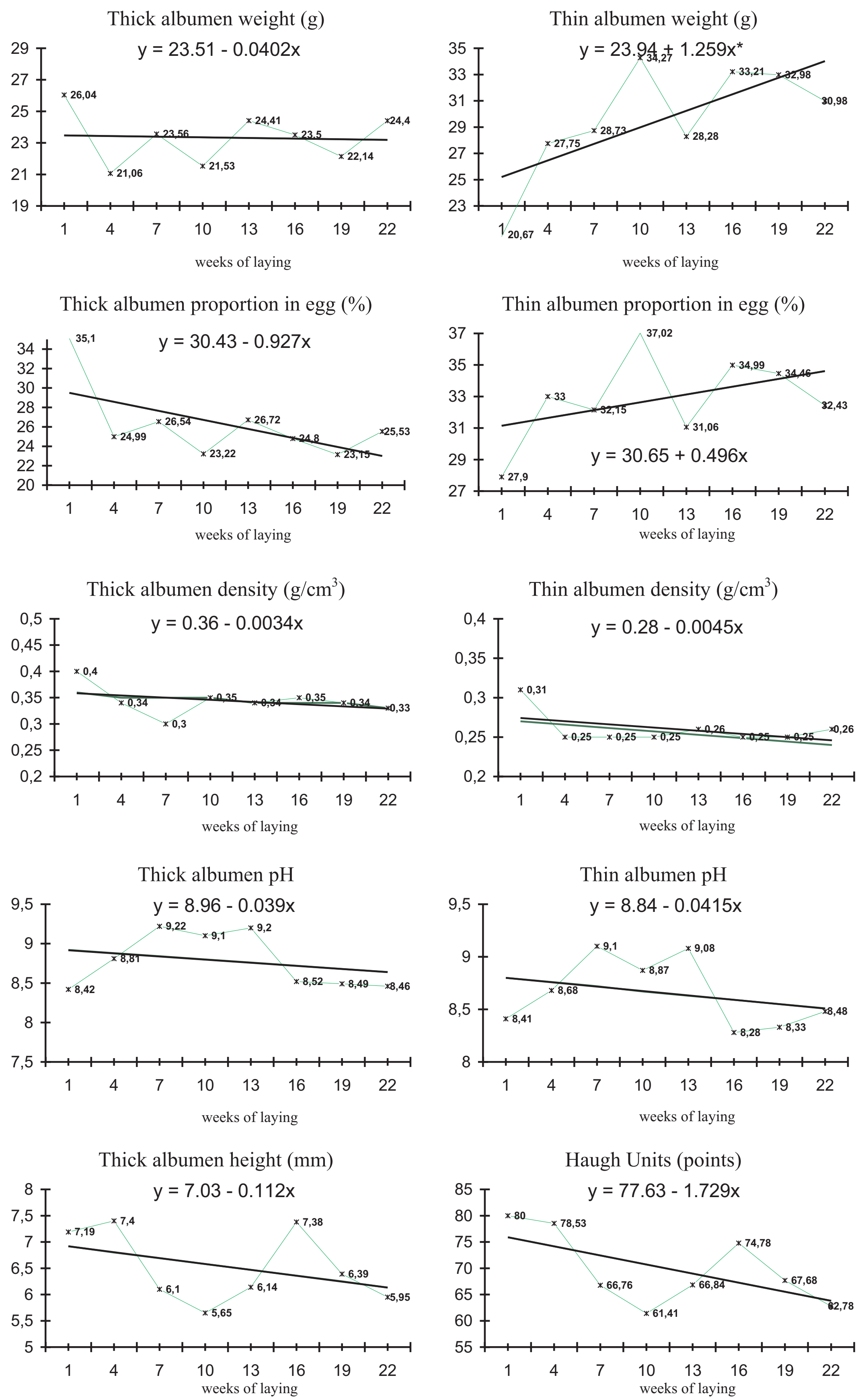

Fig. 4. Time trends of egg albumen traits and Haugh Units. * Statistically significant time trend (P≤0.05).

A decrease in the yolk colour intensity during intensive lay was due to a loss of pigments in the bird body. The intensity of the yolk colour throughout lay was similar and greater than that reported by GÓRSKI *et al*. (1998) in the eggs of ducks of the same origin. The yolk colour in 12 preservation groups (KĄŻKIEWICZ & BEDNARCZYK 1996), was much more intensive (from 6.6 to 7.5 points) than in the present research. Despite increasing egg yolk dimensions over lay, its index was similar, which could have been due to a decreasing yolk density over production.

In the present research it was also found that the decrease in the weight and the percentage share of thick albumen in the egg at the peak production and at the end of lay coincided with an increase in the weight and percentage share of thin albumen, which may be due to a decreasing thickness of the albumen fraction and thick albumen height in older birds, and thus decreasing Haugh unit score, which shows a deteriorating egg quality over lay.

In goose eggs the density of albumen was lower at the beginning of lay, as compared with the density of albumen at the peak production and at the end of lay (MAZANOWSKI and ADAMSKI 2002), while in the present research both the density of thick and thin albumen over lay decreased, which was also confirmed in another experiment (ADAMSKI 2004).

The thick albumen pH values were higher than the values of thin albumen pH. The alkaline pH reaction and an increased share of thin albumen in the egg during lay must have been due to the thick albumen becoming thinner as a result of the dissociation of the ovomucin-lysozyme complex (TRZISZKA 2000), which could be due to the deteriorating biological value of the egg at the end of lay

To recapitulate, as an increase in the egg weight and surface area, shell thickness and density as well as the number of pores throughout the shell occurred over the laying period. The egg contents analysis suggests that over lay there was an increase in the weight and percentage share of yolk and thin albumen, and a decrease in the weight and share of thick albumen and the density of yolk and both albumen fractions as well as the thick albumen height and Haugh unit score, which deteriorates the biological value of the egg. The evaluation of the egg structure traits in ducks calls for further research which would determine the relationship between changing egg traits over lay.

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