LAYER AGE AND QUALITY OF PHARAOH QUAIL EGGS

WIEK NIOSEK A JAKOŚĆ JAJ PRZEPIÓREK FARAON

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ABSTRACT

The quality of Pharaoh quail eggs obtained at 8, 13, 18 and 23 weeks of age was evaluated. Eggs laid by the oldest quail were characterized by the greatest weight (12.2 g), length (32.6 mm), width (25.8 mm) and shell surface area (25.3 cm^2). The lowest shell weight was found in eggs from the youngest quail (0.9 g), and the lowest shell proportion (8.2%) was characteristic of eggs from the oldest layers. The oldest quail (23 weeks old) produced eggs with the highest weight and albumen index, and the lowest yolk content. In addition, eggs from 23-week-old layers had the highest height of thick albumen (5.0 mm) and yolk (11.1 mm) after breaking open the egg. Layer age had a significant effect on pH of egg albumen and yolk.

Keywords: age, egg quality, Pharaoh quail

STRESZCZENIE

Oceniono jakość jaj przepiórek Faraon pozyskanych w 8, 13, 18 i 23 tygodniu ich życia. Jaja zniesione przez najstarsze przepiórki charakteryzowały się największą masą (12,2 g), długością (32,6 mm), szerokością (25,8 mm) i powierzchnią skorupy (25,3 cm^2). Najmniejszą masę skorupy miały jaja pozyskane od najmłodszych przepiórek (0,9 g), natomiast najmniejszym jej udziałem (8,2%) cechowały się jaja najstarszych niosek. Najstarsze przepiórki (23-tygodniowe) znosiły jaja o największej masie i indeksie białka oraz najmniejszej zawartości żółtka. Jaja od 23-tygodniowych niosek miały ponadto największe wysokości białka gęstego (5,0 mm) i żółtka (11,1 mm) po wybiciu ich treści. Stwierdzono istotny wpływ wieku niosek na odczyn białka i żółtka badanych jaj.

Słowa kluczowe: jakość jaja, przepiórka Faraon, wiek

DETAILED ABSTRACT

Określono wpływ wieku na skład morfologiczny i jakość jaj przepiórek Faraon. Ocenie poddano 120 jaj przepiórczych. Jaja pozyskano w 8., 13., 18. i 23. tygodniu życia przepiórek, za każdym razem po 30 jaja. Badania jaj wykonano w ciągu 24

godzin po ich zebraniu. Ptaki utrzymywano w pomieszczeniu zamkniętym, o regulowanych parametrach środowiska, w skrzyni na podłodze z plastikowej siatki. Ptaki żywiono przemysłową pełnoporcjową mieszanką dla niosek przepiórczych. Wykazano, że jaja pozyskane od 23-tygodniowych przepiórek (najstarsze ptaki) miały największą masę, długość, szerokość i powierzchnię skorupy. Wraz z wiekiem nastąpiło pogorszenie jakości skorupy (mniejsze wartości) wyrażonej jej grubością i elastycznym odkształceniem. Udział skorupy i żółtka był najmniejszy, a białka największy w jajach pozyskanych od najstarszych niosek. Jaja zniesione przez 23-tygodniowe przepiórki, w porównaniu z pozyskanymi od młodszych niosek, cechowały się największą masą, wysokością i indeksem białka i żółtka oraz istotnie jaśniejszą barwą żółtka.

INTRODUCTION

Quail are the smallest birds raised for meat and eggs (Panda and Singh, 1990). Pharaoh meat quail were developed in the United States (Kraszewska-Domańska, 1978) through selection of Japanese quail for increased body weight. Pharaoh quail have the highest body weight and lay heaviest eggs of all quail breeds. They are very well suited for broiler production and for raising on hunting grounds (Jabłoński and Gorazdowski, 2004).

Polish and foreign literature provides little information on the physical composition and quality of eggs from Pharaoh eggs. This is due to the fact that Japanese quail are the breed of choice for egg production.

Research showed that egg quality traits are affected by factors such as genetic structure of the flock (Rajkumar et al., 2009), nutrition (Güçlü et al., 2008), bird origin (Lewko and Gornowicz, 2009; Szczebińska et al., 1998), and living conditions (Calik et al., 2004; Holt et al., 2010). Egg morphology and quality is also significantly influenced by layer age (Akyurek and Okur, 2009; Esen et al., 2010; Hasan and Okur, 2009; Kokoszyński et al., 2007a, 2007b; Nowaczewski et al., 2010; Silversides and Scott, 2001; Yannakopoulos and Tserveni-Gousi, 1986).

Yannakopoulos and Tserveni-Gousi (1986) observed that as Japanese quail age, the weight of their eggs and shells increases but shell thickness decreases. In a study with Japanese quail, Nowaczewski et al. (2010) also found a significant effect of bird age on egg quality.

The relationship between egg traits and age in farmed birds has been a subject of research in other poultry species. Silversides and Scott (2001), who studied hen eggs, found that yolk size increases the most rapidly with age. Akyurek and Okur (2009) reported significant increases in the weight of egg, yolk and albumen as hens became older. Kokoszyński et al. (2007a) showed that as Pekin ducks aged, egg albumen weight, yolk percentage and yolk diameter increased while shell percentage decreased and yolk quality (expressed as yolk index) deteriorated. In pheasants,

weight of shell, yolk and albumen as well as yolk and albumen indices were found to increase significantly with age (Esen et al. 2010).

The aim of the study was to determine the effect of age on physical composition and interior quality of eggs from Pharaoh quail.

MATERIAL AND METHODS

The study was carried out in 2010 at the Faculty of Poultry Breeding of the University of Technology and Life Sciences in Bydgoszcz. The experiment used Pharaoh quail (*Coturnix Coturnix pharaon*) eggs obtained from the experimental farm in Wierzchucinek near Bydgoszcz. Physical composition and interior quality of the eggs were evaluated at 8, 13, 18 and 23 weeks of age, within 24 h of collection. Thirty eggs were analysed at each evaluation time.

Throughout the study, 35 birds were maintained in confinement under normal environmental conditions, in a box of 1.05 m^2 area. During the egg production period, quail were fed *ad libitum* commercial feed for laying quail (Golpasz S.A.).

Egg weight was determined to 0.1-g accuracy using a Medicat laboratory balance. Egg length (along the longitudinal axis) and egg width (along the equatorial axis) were measured with an electronic caliper. Egg shape index was calculated as the ratio of egg width to egg length (%). Shell surface area was calculated using the formula of Paganelli et al. (1974):

$$P_s = 4.835 \times W^{0.662}$$

where: W= egg weight

Shell deformation (μm) was determined using a Marius instrument. After emptying the egg contents onto a glass table, yolk and thick albumen height was measured with a QCD instrument (TSS). Albumen index was calculated as the ratio of thick albumen to its average diameter.

Yolk diameter along the chalazae line was determined with the caliper. The ratio of the yolk height to its diameter constituted the yolk index. Yolk colour was determined with the 15-point scale of La Roche. After the completion of measurements on the egg content the thin albumen, the thick albumen and the yolk were separated and their pH determined with a Matthaüs pH meter.

The eggshell, after the removal of the egg content, was dried, weighed (g) on Medicat scales and measured for thickness (mm) with an electronic micrometer screw. The albumen weight was calculated from the difference between the egg weight, and the yolk and shell weight.

The numeric data gathered was analysed statistically and the mean values ($\bar{x}$) and coefficients of variation (CV) of the studied traits were calculated. Analysis of variance was performed. Significance of differences between the mean values of the traits was tested with Student's t-test.

RESULTS AND DISCUSSION

The mean weight of eggs (Tab. 1) from Pharaoh quail aged 23 weeks was significantly higher than the weight of eggs obtained from younger layers. The increase in mean egg weight with the age of Japanese quail was also noted by Seker et al. (2004) who compared eggs collected at 10 weeks (10.95 g) and at 20 weeks of age (11.32 g). Yilmaz-Dikmen and Ipek (2006) and Vali et al. (2006) found that the weight of Japanese quail eggs collected at different ages first increased and later decreased. Nowaczewski et al. (2010), who analysed eggs obtained from 9-, 25- and 31-week-old quail found a significant decrease, which was followed by a non-significant increase in weight in older layers.

Tabela 1. Masa i wymiary jaj przepiórek faraon w zależności od wieku
Table 1. Weight and dimensions of the Pharaoh quail eggs depending on age

Trait	Characteristic	Week of age			
		8	13	18	23
Egg weight, g	$\bar{x}$	10.2^{b}	11.1^{c}	10.5^{b}	12.2^{a}
	CV	11.4	8.9	7.8	11.2
Egg length, mm	$\bar{x}$	31.3^{b}	32.1^{a}	31.7^{a}	32.6^{a}
	CV	5.5	3.6	7.2	6.2
Egg width, mm	$\bar{x}$	24.4^{b}	25.2^{ac}	24.7^{bc}	25.8^{a}
	CV	3.9	4.6	3.3	3.1
Egg shape index, %	$\bar{x}$	77.9	78.5	77.9	79.1
	CV	5.6	4.1	6.2	3.7
Eggshell surface, cm^2	$\bar{x}$	22.5^{b}	23.8^{c}	22.9^{b}	25.3^{a}
	CV	7.6	5.9	5.2	7.5

a, b, c – mean values of traits in rows with different letters differ significantly (P≤0.05)

Egg length and width were the highest on the last measurement date (32.6 and 25.8 mm, respectively). The lowest values of these traits were found in quail at 8 weeks of age (31.3 and 24.4 mm). Similar results for these traits were reported by Kul and Seker (2004) who evaluated eggs from 20-week-old Pharaoh quail (33.4 mm long, 25.0 mm wide). Kokoszyński et al. (2007a) found the length and width of duck eggs

to increase during early egg production. Rajkumar et al. (2009), who studied the effect of naked-neck chicken on the quality of their eggs found the lowest egg length and width on the first evaluation date, and the largest egg length in the final week of the study.

At 8 and 18 weeks of age, Pharaoh quail produced the most elongated eggs (77.9%). The highest egg shape index (79.1%) was found at 23 weeks of age, which showed that the eggs became more oval in shape. Lower egg shape index in Pharaoh quail (76.43%) was obtained by Genchev (2009) for eggs from 13- and 14-week-old birds. A higher value of this trait (80.13%) was observed by Tarasewicz et al. (2004) for eggs from 18-week-old Pharaoh quail. Yannakopoulos and Tserveni-Gousi (1986) found the egg shape index of Japanese quail to decrease between 49 and 154 days of age.

Shell surface area was the largest in eggs collected from quail at 23 weeks of age (25.3 cm^2) and the smallest on the first evaluation date (22.5 cm^2). Larger shell surface area in Pharaoh quail eggs was obtained by Szczerbińska et al. (1998) at 13 weeks of age (25.91 cm^2) and by Genchev (2009) - 29.43 cm^2.

Tabela 2. Cechy skorupy jaj przepiórek faraon w zależności od wieku
Table 2. Shell traits of the Pharaoh quail eggs depending on age

Trait	Characteristic	Week of age			
		8	13	18	23
Eggshell weight, g	$\bar{x}$	0.9^{b}	1.0^{a}	1.0^{a}	1.0^{a}
	CV	9.4	8.9	9.4	15.7
Eggshell proportion related to egg, %	$\bar{x}$	8.8^{a}	9.0^{a}	9.5^{a}	8.2^{b}
	CV	10.1	9.1	5.8	7.9
Eggshell thickness, mm	$\bar{x}$	0.226^{a}	0.223^{a}	0.221^{ab}	0.208^{b}
	CV	9.2	8.1	7.2	12.9
Eggshell deformation, µm	$\bar{x}$	49.7^{b}	54.8^{c}	61.8^{a}	62.3^{a}
	CV	15.9	19.5	21.9	20.9

a, b, c – mean values of traits in rows with different letters differ significantly (P≤0.05)

Eggs collected from 8-week-old quail were characterized by the lightest shell (0.9 g) (Tab. 2). On the next evaluation dates, the value of this trait was identical and significantly higher (1.0 g). The smallest shell weight (0.84 g) from Japanese quail eggs was obtained by Kul and Seker (2004), and higher shell weight (1.13- 1.17 g) by Tarasewicz et al. (2006). Yilmaz-Dikmen and Ipek (2006) reported that eggshell weight in quail increased gradually with age. Dańczak et al. (1997) found the weight of eggshell from old birds to decrease, but the difference was not significant.

Eggshell percentage varied between 8.2 and 9.5%. Other studies on the quality of Pharaoh quail eggs showed higher values of this trait (Tarasewicz et al., 2004, 2006). The gradual decrease in shell percentage with layer age was also reported for duck eggs (Kokoszyński et al. 2007a).

Eggshell thickness decreased with the age of the birds from 0.226 to 0.208 mm. Yannakopoulos and Tserveni-Gousi (1986) found eggshell thickness of quail eggs to decrease between 49 and 154 days of age. On the other hand, Dańczak et al. (1997) showed that the eggs from older quail have thicker shells, increasing non-significantly from 206.2 to 216.0 µm.

The smallest shell deformation (49.7 µm) was characteristic of eggs from 8-week-old quail. The value of this trait increased with layer age (Tab. 2). Contrary results were obtained by Zita et al. (2009) for ISA Brown commercial hybrids.

The analysis of eggshell content (Tab. 3) showed that except 18 weeks of age, egg albumen weight increased with quail age. Yilmaz-Dikmen and Ipek (2006) found the smallest albumen weight in the eggs collected on the first evaluation date (6.97 g), and the highest on the last evaluation date (7.25 g).

Tabela 3. Cechy treści jaj przepiórek faraon w zależności od wieku
Table 3. Traits of the Pharaoh quail eggs depending on age

Trait	Characteristic	Week of age			
		8	13	18	23
Albumen weight, g	$\bar{x}$	6.5^{b}	7.0^{a}	6.2^{b}	7.9^{c}
	CV	14.7	9.6	8.7	13.7
Albumen proportion related to egg, %	$\bar{x}$	63.7^{a}	63.1^{a}	59.0^{b}	64.8^{a}
	CV	6.1	5.7	5.2	7.0
Yolk weight, g	$\bar{x}$	2.8^{a}	3.1^{b}	3.3^{b}	3.3^{b}
	CV	14.8	17.9	14.1	17.5
Yolk proportion related to egg, %	$\bar{x}$	27.5^{b}	27.9^{b}	31.5^{a}	27.0^{b}
	CV	13.1	12.6	9.9	16.5
Thick albumen height, mm	$\bar{x}$	3.9^{c}	3.5^{b}	3.4^{b}	5.0^{a}
	CV	20.3	16.8	15.0	6.5
Thin albumen index,	$\bar{x}$	0.10^{b}	0.09^{b}	0.09^{b}	0.13^{a}
	CV	19.0	21.7	20.7	7.2
Yolk height, mm	$\bar{x}$	9.8^{c}	9.9^{c}	10.5^{b}	11.1^{a}
	CV	24.4	7.6	6.7	8.8

Yolk diameter, mm	$\bar{x}$	23.1^{bc}	24.4^{a}	23.4^{b}	23.6^{ab}
	CV	5.9	7.8	6.1	9.7
Yolk index, %	$\bar{x}$	42.4^{ab}	40.6^{b}	44.9^{a}	47.0^{a}
	Cv	26.4	12.5	10.4	12.8
Yolk colour, scores	$\bar{x}$	7.3^{c}	7.7^{c}	8.3^{a}	6.2^{b}
	CV	13.6	6.1	5.7	10.2

a, b, c – mean values of traits in rows with different letters differ significantly (P≤0.05)

The lowest and highest albumen percentage was found in the eggs from 18- and 23-week-old quail, respectively (Tab. 3) Szczerbińska et al. (1998) reported the lowest egg albumen percentage in 13-week-old Pharaoh quail (58.55%). In a study with eggs from ISA-White and ISA-Brown commercial hybrids, the highest egg albumen percentage was found on the first date, and the lowest on the last evaluation date (Silversides and Scott, 2001).

Yolk weight ranged from 2.8 to 3.3 g and increased as quail became older. Yannakopoulos and Tserveni-Gousia (1986) showed egg yolk weight in Japanese quail to increase with layer age. In pheasants, Esen et al. (2010) obtained greater yolk weight in the eggs of older birds.

The proportion of egg yolk in quail increased to 18 weeks of age and then decreased significantly. The proportion of yolk in the eggs of 18-week-old Pharaoh quail investigated by Tarasewicz et al. (2004) was 30.19%. Nowaczewski et al. (2010), who studied eggs from 9-, 25- and 31-week-old Japanese quail, initially found a significant decrease in yolk egg percentage (29.75%), followed by an increased value of this trait (30.88%).

The height of thick albumen decreased to 18 weeks of age, but increased significantly on the last evaluation date, which was also associated with greater egg weight. Higher thickness of thick albumen (5.06 mm) in Pharaoh quail was obtained by Genchev (2009) for the eggs from birds aged 13 and 14 weeks. Dańczak et al. (1997) found thick albumen height in quail eggs to increase with age.

Thick albumen index achieved the highest value on the last evaluation date (0.13), and the lowest value during the evaluation of eggs from 13- and 18-week-old quail (0.09). Contrary results concerning albumen index were reported for pheasant eggs evaluated in three successive years of egg production (Esen et al. 2010).

Yolk height ranged from 9.8 mm to 11.1 mm and increased as quail became older. Smaller yolk height (9.39 mm) after breaking open the eggs obtained from 20-week-old Japanese quail was reported by Kul and Seker (2004).

Yolk diameter was the lowest in the eggs from the youngest (8-week-old) quail (23.1 mm). The largest yolk diameter was found in the eggs laid by 13-week-old birds (24.4 mm). In a study by Yilmaz-Dikmen and Ipek (2006) with eggs from 9-, 14- and 20-week-old Japanese quail, yolk diameter was the largest on the second evaluation date (22.08 mm) and the lowest on the first (20.55 mm).

Yolk index was the highest on the last evaluation date (47.0%) and the lowest when quail were 13 weeks old (40.6%). Similar results were obtained by Nagarajan et al. (1991), who found egg yolk index to be higher in birds aged 18, 22 and 26 weeks compared to 10-week-old birds. Nowaczewski et al. (2010) showed the quail egg yolk index to decrease with age from 49.18% to 47.67%. The decrease in the yolk index of eggs obtained from older birds was also found when analysing the eggs obtained from other species of poultry such as turkeys (Hristiakieva et al., 2009) and laying hens (Akyurek and Okur, 2009).

Yolk colour intensity increased to 18 weeks, following which it decreased significantly. Nagarajan et al. (1991) found yolk colour intensity in Japanese quail eggs to increase with age. Also in the eggs from Pekin ducks, more intensive yolk colour was observed in older birds (Kokoszyński et al. 2007a).

Quail eggs collected at 8 weeks of age were characterized by the highest pH of thin albumen (Tab. 4), with the lowest values found on the second and on the last evaluation date (9.0). Analysis of thick albumen revealed that its pH at 8, 13 and 18 weeks was similar (9.1) except 23 weeks when it was lower (9.0). An earlier study

(Tarasewicz et al. 2005) with eggs from 12-week-old Pharaoh quail found lower pH of albumen. A study by Lapâo et al. (1999) on hen eggs showed significantly higher values of albumen pH in the eggs of older birds (an increase from 8.08 to 8.30).

Tabela 4. Odczyn treści jaj przepiórek faraon w zależności od wieku
Table 4. pH of the Pharaoh quail eggs depending on age

Trait	Characteristic	Week of age			
		8	13	18	23
pH level of thin albumen	$\bar{x}$	9.2^{a}	9.0^{c}	9.1^{b}	9.0^{c}
	CV	1.1	1.0	1.1	1.0
pH level of thick albumen	$\bar{x}$	9.1^{a}	9.1^{a}	9.1^{a}	9.0^{b}
	CV	1.4	1.0	1.0	1.0
pH level of yolk	$\bar{x}$	6.2^{b}	6.3^{a}	6.3^{a}	6.2^{b}
	Cv	3.7	2.5	1.3	1.4

a, b, c – mean values of traits in rows with different letters differ significantly (P≤0.05)

Yolk pH on the first and last evaluation date was identical (6.2), and the same situation occurred at 13 and 18 weeks (6.3). Lower pH of yolk was found in a study by Tarasewicz et al. (2005) with Pharaoh quail eggs collected at 12 weeks of age. Okruszek et al. (2006), who evaluated the effect of duck age on egg quality showed significantly lower pH of yolk from the eggs of older birds.

CONCLUSIONS

The eggs collected from 23-week-old Pharaoh quail were characterized by the greatest weight, length, width and shell area, and the highest egg shape index. The eggs from 8-week-old (youngest) quail were characterized by the lowest shell weight and shell deformation. The oldest quail produced eggs with the highest weight of albumen and yolk, which after breaking open had the highest height. The eggs collected from 8-week-old layers had the most alkaline pH of thin albumen. The pH of thick albumen was the same on the first three evaluation dates and significantly lowers at 23 weeks. The yolk of eggs from 8- and 23-week-old quail was characterized by significantly higher acidity.

REFERENCES

Akyurek H., Okur A. A., (2009) Effect of storage time, temperature and hen age on egg quality in free-range layer hens. Journal of Animal and Veterinary Advences, 8, 1953-1958.

Calik J., Połtowicz K., Krawczyk J., Wężyk S., (2004) Changes in quality characteristics of eggs from caged and barn system during storage at different conditions. Mat. 69. Zjazdu PTZ, Siedlce, 87-88. [in Polish]

Dańczak A., Z. Tarasewicz, D. Szczerbińska, M. Ligocki., (1997) The relationship between fowl age and hatchability in Japanese quails (*Coturnix C. Japonica*). Zeszyty Naukowe PTZ (1997) 32, 109-117. [in Polish]

Esen F., Ozbey O, Genc F., (2010) The effect of age on egg production, hatchability and egg quality characteristics in pheasants (*Phasianus colchicus*). Journal of Animial and Veterinary Advences, 9, 1237-1241.

Genchev A., (2009) Influence of hatching eggs storage period upon the incubation parameters in Japanese quails. Journal of Central European Agriculture, 10, 167-174.

Güçlü B.K., Uyanik F., Iscan K.M., (2008) Effects of dietary oil sources on egg

quality, fatty acid composition of eggs and blood lipids in laying quail. South African Journal of Animal Science, 38, 91-100.

Hasan A., Okur A. A., (2009) Effect of storage time, temperature and hen age on egg quality in free-range layer hens. Journal of Animal and Veterinary Advences, 8, 1953-1958.

Holt P. S., Davies R.H., Dewulf J., Gast R.K., Huwe J.K., Jones D.R., Waltman D., Willian K.R., The impact of different housing systems on egg safety and quality. Proceedings of the Symposium in Denver, Colorado, July 11-15. 2010.

Hristakieva P., Oblakova M., Lalev M. (2009) Incubation and vital morphological traits in eggs from age-related turkeys. Trakia Journal of Sciences, 7, 63-67.

Jabłoński K.M., Gorazdowski M.J. Quails and partridges. Ed. Egros, Warszawa, 2004 [in Polish]

Kokoszyński D., Korytkowska H. Korytkowski B., (2007a) Evaluation on physical traits and morphological composition of Pekin duck eggs from P44. Acta Scientiarum Polonorum, Zootechnica 6, 21-28. [in Polish]

Kokoszyński D., Bernacki Z., Korytkowska H., (2007b) Eggshell and egg content traits in Pekin duck eggs from the P44 reserve flock raised in Poland. Journal of Central European Agriculture, 8, 9-16.

Kraszewska-Domańska., Quails. PWRiL Warszawa, 1978. [in Polish]

Kul S., Seker I., (2004) Phenotypic correlations between some external and internal Egg quality traits in the Japanese quail (*Coturnix coturnix japonica*). International Journal of Poultry Sciences, 3: 400-405.

Lapâo C., Gama L.T., Soares M.C., (1999) Effects of broiler breeder age and length of egg storage on albumen characteristics and hatchability. Poultry Science, 78, (5), 640-645.

Lewko L., Gornowicz E., (2009) Egg albumen quality as affected by bird origin. Journal of Central European Agriculture, 10, 455-464.

Nagarajan S., Narahari D., Jayaprasad I.A., Thyagarajan D., (1991) Influence of stocking density and layer age on production traits and egg quality in Japanese quail. British Poultry Science, 32, 243-248.

Nowaczewski S., Kontecka H., Rosiński A., Koberling S., Koronowski P., (2010) Egg quality of Japanese quail depends on layer age and storage time. Folia biologica (Kraków), 58, 201-207.

Okruszek A., Książkiewicz J., Wołoszyn J., Kisiel T., Orkusz A., Biernat J.,(2006) Effect of laying period and duck origin on egg characteristics. Archiv für Tierzucht 49, 400-410.

Paganelli C.V., Olszowska A., Ar A., (1974) The avian egg: surface area, volume, and density. The Condor, 76, 319-325.

Panda B., Singh R.P., (1990) Development in processing quail. World's Poultry Science Journal, 46, 219-234.

Popova-Ralcheva S., Sredkova V., Valchev G., Bozakova N., (2009) The effects of the age and genotype on morphological egg quality of parent stock hens. Archiva Zootechnica, 12, 24-30.

Rajkumar U., Sharma R.P., Rajaravindra K.S., Niranjan M., Reddy B.L.N, Bhattacharya T.K., Chatterjee R.N., (2009) Effect of genotype and age on egg quality traits in naked neck chicken under tropical climate from India. International Journal of Poultry Sciences, 8, 1151-1155.

Seker I., Kul S., Bayraktar M., (2004) Effects of parental age and hatching egg weight of Japanese quails on hatchability and chick weight. International Journal of Poultry Sciences, 3, 259-265.

Silversides F. G., Scott T. A., (2001) Effect of storage and layer age on quality of eggs from two lines of hens. Poultry Science, 80:, 1240–1245.

Szczerbińska D., Sitkowska A., Tarasewicz Z., (1998) A relationship between breed and quail egg quality. Zeszyty Naukowe PTZ 36: 391-397.[in Polish]

Tarasewicz Z., Szczerbińska D., Ligocki M., Dańczak A., Majewska D., Kurzawa J., (2004) Effect of the origin of quails on their utility type and selected egg quality traits. Electronic Journal of Polish Agricultural Universities, 7.

Tarasewicz Z., Szczerbińska D., Ligocki M., Dańczak A., Majewska D., Romaniszyn K., (2005) The effect of a low-protein diet on Japanese quail rearing, egg quality and hatchability. Journal of Animal Feed Sciences,14: 499-502.

Tarasewicz Z., Szczerbińska D., Ligocki M., Wiercińska M., Majewska D., Romaniszyn K., (2006) The effect of differentiated dietary protein level on the performance of breeder quails. Animal Science Papers and Reports, 24, 207-216.

Vali N., Edriss M.A., Moshtaghi H., (2006) Comparison of egg weight between two quail strains. International Journal of Poultry Sciences, 5, 394-400.

Yannakopoulos A. L., Tserveni-Gousi A.S., (1986) Quality characteristics of quail eggs. British Poultry Science, 27, 171-176.

Yilmaz-Dikmen B., Ipek A., (2006) The Effects of shank length on egg production and Egg quality traits of Japanese quails (*Coturnix coturnix japonica*). EPC 2006 – XII European Poultry Conference, Verona, Italy, September 10-14. 2006.

Zita L., Tůmová E, Štolc L., (2000) Effects of genotype, age and their interaction on egg quality in brown-egg laying hens. Acta Veterinaria Brno, 78, 85-91.