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EFFECT OF FEED SUPPLEMENTATION WITH ORGANIC SELENIUM AND VITAMIN E ON PHYSICAL CHARACTERISTICS OF JAPANESE QUAIL (*COTURNIX JAPONICA*) EGGS

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Key words: Japanese quail, egg physical characteristics, selenium, vitamin E

Effect of feed supplementation with organic selenium and vitamin E on physical characteristics of Japanese quail eggs collected at the beginning (1st month of production), peak (4th month) and at the end of laying cycle (10th month) was evaluated.

Sexually matured quail females were divided into two groups (48 birds each). From the first day of live to the end of the laying period the control group (CG) was fed the basic feeds (appropriate to birds age), while the experimental group (EG) with feeds supplemented with 0.3 mg/kg selenium (as 300 mg of selenium yeast – Sel-Plex®, Alltech LTD, USA) and 100 mg/kg vitamin E (200 mg/kg of E-50 Adsorbate – Rolimpex S.A).

For each group and laying period 20 eggs were collected and at the day of collection the following parameters were evaluated individually: egg weight; weight of shell, egg white, yolk and their percentage content in relation to the egg weight; height of yolk and egg white; width and color of yolk; thickness and strength of shell, as well as the yolk index and Haugh units.

At the beginning of the laying cycle the weight of egg collected from both groups was similar (averaged 9.15 g in EG and 8.96 g in CG), and significantly lower ($p \leq 0.05$) (by 1.75 g and 1.97 g, respectively) when compared with subsequent analysed periods. However, in any period of the laying cycle differences in egg weight were significant.

For all evaluated periods the yolk weight (4.3 g), yolk ratio (44.0%) and yolk index (5.21%) of eggs collected from the CG were higher ($p \leq 0.05$) in relation to the EG (4.1 g; 40.8% and 4.8%, respectively). Contrary to yolk, the weight and index of egg white in eggs collected from the CG at the beginning and peak of laying cycle (3.98 g; 38.9%) were significantly ($p \leq 0.05$) lower comparing to the EG (4.45 g; 43.1%).

Regarding the egg shell weight, significant ($p \leq 0.05$) differences between evaluated groups were stated only at the peak of the laying cycle however, in the CG the shell index at the beginning (18.91%), peak (17.13%) and for the entire laying cycle (17.0%) was significantly ($p \leq 0.05$) higher when comparing to the EG (16.69%; 15.15% and 15.95%, respectively). Also the shell thickness of eggs collected from the CG (0.22 mm) was higher ($p \leq 0.05$) than in the EG (0.17 mm). Feed supplementation with organic selenium and vitamin E increased significantly ($p \leq 0.05$) the shell strength, for entire cycle it averaged 13.4 N for the experimental group and 10.5 N for the control group.

INTRODUCTION

Japanese quails (*Coturnix japonica*) are characterised by quick pursuing of sexual maturity, high level of egg laying and small environmental requirements, as well as quite low production costs [Gonzalez, 1995]. Those traits predispose quails, both in Polish and also world's research centers, to be used as model birds in basic studies such as embryological, physiological, genetic and nutritional experiments [Ottinger, 2001; Minvielle, 2004]. Moreover, in many countries, for example France, Italy, Greece, Japan and China, quail eggs and meat are consider as dietetic products, rich in vitamins and mineral substances [Gonzalez, 1995; Panda & Singh, 1990]. However, in Poland quail products are still underestimated.

Taking under consideration the economical aspects of quails production, the level of egg laying, birds survival rate and physical traits of obtained eggs are the most crucial factors [Lin *et al*., 2004]. Those factors are dependent on bird's genotype [Vali *et al*., 2006], layers age [Gonzalez, 1995], housing system and environmental conditions *i.e.* microclimate [Ozbey *et al*., 2004; Śmiechowska & Dmowski, 2005], as well as on composition of feedstuffs [Oliveira *et al*., 2007]. It is necessary to provide a well balanced fodder and perfect housing conditions in order to obtain high level of egg laying when keeping poultry lines of high productivity. In that case natural antioxidants, such as selenium and vitamin E, are of great importance in keeping birds in a good state of health with high egg laying level [Surai, 2002; Sahin *et al*., 2002; Renema & Sefton, 2004].

Selenium is one of the basic microelements, which are recommended in farm animals feeding, including poultry. Selenium activity is usually considered in the close relation, with vitamin E and sulphur-contained amino acids [Arthur, 1997]. Until now, there have been only a small number of research carried out on the effect of antioxidants on physical characteristics of quail eggs. Most of them were performed on birds kept at high temperature [Sahin & Kucuk, 2001ab; Sahin *et al*., 2002]. The objective of the study was to evaluate the effect of feed supplementation with organic selenium and vitamin E on physical characteristics of Japanese quail eggs collected during the entire laying period.

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MATERIALS AND METHODS

Freshly hatched quails were randomly divided into two groups: the control group (CG) fed, from the first day of live to the end of the laying cycle, with the basic feeds (appropriate to birds age) and the experimental group (EG) fed with feeds supplemented with 0.3 mg/kg selenium (as 300 mg of selenium yeast – Sel-Plex®, Alltech LTD, USA) and 100 mg/kg vitamin E (200 mg/kg of E-50 Adsorbate – Rolimpex S.A).

Birds were reared on a deep litter and in controlled environment (temperature, lighting program, humidity) and given appropriate conditions of existence.

From sexually matured flocks (at 7th week of age) 48 females were selected for further experiment and placed into two 4-tier battery cages (1.0x 0.55x0.3 m of each level and for 12 birds). All cages were kept indoor at temperature 22-24^{o}C. During the production period birds were treated with 14 h light/10 h dark cycle. Water and feed were available *ad libitum*.

Egg analysis. The eggs collected at the beginning (1st month of production), peak (4th month) and at the end of laying period (10th month) were evaluated at the day of collection.

From each group and laying period, in 20 eggs were evaluated individually: egg weight; weight of shell, egg white, yolk and their percentage content in relation to the egg weight; height of yolk and egg white; width and color of yolk; thickness and strength of shell, as well as the yolk index and Haugh units.

All traits were evaluated with the use of specific equipment for egg quality analysis QCM+ TSS (Technical Services and Supplies). The strength of shell was analysed on Zwick/Roell machine by using the compression test until the first breakage of the shell.

Data obtained were analysed by ANOVA and Duncan's multiple range test (Statistica, 7.1).

The presented experiment was approved by the II Local Ethics Commission for Experiments Carried on Animals.

RESULTS AND DISCUSSION

Feed supplementation with organic selenium and vitamin E did not affect significantly the egg weight. In every evaluated period (beginning, peak and the end) it was similar and averaged for the entire laying cycle 10.16 g in the experimental group (EG) and 9.95 g in the control group (CG) (Table 1). These results are comparable to data reported by Jiakui & Xiaolong [2004] in the case of quails eggs, as well as those published by Utterback *et al*. [2005] for hen eggs. Moreover, Sahin *et al*. [2002] did not state any significant effect of vitamin E addition to fodder (125 mg/kg feedstuffs) on egg weight. Our study demonstrated that egg weight in both analysed groups was significantly ($p \leq 0.05$) higher at the end of laying cycle (10.90 g for EG and 10.93 g for CG groups, respectively) in comparison to the eggs collected at the beginning of laying period (9.15 g (EG) and 8.96 g (CG)). Similar tendency was observed for quail eggs by Gonzalez [1995], who reported statistically significant increase in egg weight from 9.67 g in the second month of quails life to 10.60 g for eggs collected in the tenth month of living. Moreover, research carried out by Vali *et al*. [2006] confirmed a significant increase in egg weight between the third (11.11 g) and seventh month of quails life (11.73 g). However, at the end of laying period (12th month) egg weight decreased significantly (10.84 g).

The egg yolk weight, percentage content of yolk and shell in relation to whole egg weight in the CG group were significantly ($p \leq 0.05$) higher (4.30 g; 44.01% and 17.04%, respectively) than in the EG (4.11 g; 40.88% 15.95%, respectively) during the entire laying cycle. However, adversely to the results obtained for egg yolk, eggs collected from quails fed with fodder enriched with selenium and vitamin E were characterised by higher ($p \leq 0.05$) egg white weight (4.45 g) and its percentage content in relation to whole egg weight (43.18%) during the entire experiment in comparison to the eggs collected from the CG group (3.98 g and 38.95%, respectively) (Table 1).

The results obtained in our study were not consistent with those reported by Golubkina & Papazyan [2006]. Quail eggs analysed by cited authors were characterised by lower yolk and shell weights (4.4 g and 1.1 g, respectively) and also by higher egg white weight (6.9 g) than the eggs evaluated in our experiment. Moreover, in comparison to results presented in this paper, lower percentage content of yolk (32.4%) and shell (8.15%), as well as higher egg white (59.58%) content in rela-

TABLE 1. The effect of organic selenium and vitamin E addition to fodder of Japanese quails (*Coturnix japonica*) on physical characteristic of eggs during laying cycle (means±SD).

Period of laying cycle	Group	Egg weight (g)	Egg white to yolk ratio	Egg weight and percentage in relation to egg weight (%)					
				Egg yolk		Egg white		Shell	
				(g)	(%)	(g)	(%)	(g)	(%)
Beginning	Experimental	9.15±0.91	0.89^{a}±0.33	4.07^{a}±0.45	44.98^{a}±6.81	1.53±0.25	16.89^{a}±2.97	1.53±0.25	16.89^{a}±2.97
	Control	8.96±1.04	0.68^{b}±0.35	4.31^{b}±0.45	50.03^{b}±9.05	1.63±0.26	18.91^{b}±3.91	1.63±0.26	18.91^{b}±3.91
Peak	Experimental	10.46±0.82	1.20^{a}±0.27	4.07^{a}±0.43	39.0^{a}±4.22	1.58^{a}±0.17	15.15^{a}±2.03	1.58^{a}±0.17	15.15^{a}±2.03
	Control	10.29±0.67	0.97^{b}±0.25	4.31^{b}±0.39	42.58^{b}±4.56	1.73^{b}±0.23	17.13^{b}±2.70	1.73^{b}±0.23	17.13^{b}±2.70
End	Experimental	10.90±0.87	1.22±0.34	4.19±0.45	38.65±5.10	1.71±0.21	15.80±2.09	1.71±0.21	15.80±2.09
	Control	10.93±0.76	1.19±0.30	4.31±0.46	39.41±4.96	1.64±0.24	15.07±2.74	1.64±0.24	15.07±2.74
Total	Experimental	10.16±1.14	1.11^{a}±0.34	4.11^{a}±0.44	40.88^{a}±6.16	1.67±0.22	15.95^{a}±2.48	1.67±0.22	15.95^{a}±2.48
	Control	9.95±1.23	0.95^{b}±0.37	4.30^{b}±0.43	44.01^{b}±7.85	1.61±0.25	17.04^{b}±3.51	1.61±0.25	17.04^{b}±3.51

Mean values denoted by different superscripts within laying cycle differ significantly from each other (a, b – $p \leq 0.05$)

tion to whole egg weight for quails eggs obtained from three months old birds were reported by Szczerbińska *et al*. [1998].

The eggs obtained from quails referred as experimental group were characterised by the same weight of egg yolk when analysed at the beginning and peak of laying cycle (4.07 g). Whilst, at the end of the laying period slight increase in this physical parameter was observed (4.19 g). Within this group the percentage content of egg yolk in relation to the whole egg weight decreased significantly ($p \leq 0.05$) by about 5.98 percentage points (PP) between the first and second analysed laying period. In the control group weight of egg yolk was similar like in the experimental group and did not differ significantly within the entire laying cycle, whilst percentage content of egg yolk in relation to the whole egg weight decreased significantly ($p \leq 0.05$) by about 7.45 PP between the beginning and peak of laying cycle, and by about 3.17 PP between peak and the end of laying cycle.

Feeding quails with fodder supplemented with selenium and vitamin E (EG) resulted in higher ($p \leq 0.05$) egg white weight, as well as higher ($p \leq 0.05$) percentage content of egg white in relation to the whole egg weight, between eggs collected in the first and the second period of laying cycle (increase by 1.28 g and 7.7 PP, respectively). Similar relations were observed in the control group, in which egg white weight and percentage content of egg white in relation to egg weight were significantly ($p \leq 0.05$) higher by 1.28 g and 9.22 PP between the beginning and peak of laying cycle, and by 0.93 g and 5.23 PP between peak and the end of laying.

Roberts [2004] described some factors which can have an influence on egg white height and the value of Haugh units, including vitamin E addition to layer fodder. Wakebe [cited after Surai, 2002] stated the positive effect of fodder supplementation with selenium on hen eggs quality. The author mentioned above did not revealed any significant differences between Haugh units when analysed one day eggs, whereas after seven days of storage the value of Haugh units was significantly higher in eggs collected from hens fed with fodder enriched with 0.3 ppm Se/kg feed. The results obtained in our study did not show any significant influence of fodder supplementation with selenium and vitamin E on Haugh units. Whereas, egg white height analysed in the CG was significantly ($p \leq 0.05$) higher (average of about 0.19 mm) than in eggs from the EG (Table 2). Comparable results were reported by Sahin *et al.* [2002], who did not reveal any significant differences in Haugh units after addition of 125 mg/kg vitamin E to quail fodder.

The height of dense egg white fraction differed significantly ($p \leq 0.05$) during the analysed laying period when birds were fed with fodder enriched with selenium and vitamin E. At peak of laying the mentioned indicator of egg quality decreased by about 0.23 mm in relation to those measured at the beginning of experiment, whilst at the end of quails productivity it increased by about 0.26 mm. Similar tendency in height of egg white during laying quail cycle was observed by Gonzalez [1995]. The cited author reported a significant decrease in egg white height (of 1.64 mm) between eggs analysed at the second and sixth month of living, followed by a significant increase (of 0.76 mm) for eggs collected at the 9th month of quails life.

TABLE 2. The effect of organic selenium and vitamin E addition to fodder of Japanese quails (*Coturnix japonica*) on physical characteristic of eggs during laying cycle (means±SD).

Period of laying cycle	Group	Egg yolk				Egg white			Shell	
		height (mm)	width (mm)	Index (%)	colour (LaRoche)	height (mm)	pH values	Haugh units	thickness (mm)	strength (N)
Beginning	Experimental	$11.42^{a}\pm0.74$	$2.53^{a}\pm0.18$	$4.54^{a}\pm0.43$	$11.36^{a}\pm1.13$	4.82 ± 0.86	$8.81^{a}\pm0.05$	93.17 ± 3.30	$0.16^{a}\pm0.01$	$13.63^{a}\pm3.35$
	Control	$12.71^{b}\pm0.58$	$2.45^{b}\pm0.12$	$5.21^{b}\pm0.33$	$12.71^{b}\pm0.80$	4.94 ± 0.60	$8.94^{b}\pm0.02$	93.97 ± 4.33	$0.21^{b}\pm0.02$	$10.82^{b}\pm2.37$
Peak	Experimental	$12.30^{a}\pm0.76$	$2.59^{a}\pm0.18$	$4.77^{a}\pm0.49$	$11.56^{a}\pm1.23$	$4.59^{a}\pm0.58$	$8.81^{a}\pm0.04$	$90.95^{a}\pm3.68$	$0.17^{a}\pm0.01$	$12.59^{a}\pm1.32$
	Control	$12.71^{b}\pm0.47$	$2.45^{b}\pm0.11$	$5.17^{b}\pm0.25$	$12.63^{b}\pm1.23$	$5.17^{b}\pm0.59$	$8.98^{b}\pm0.07$	$94.21^{b}\pm3.03$	$0.23^{b}\pm0.02$	$9.71^{b}\pm1.97$
End	Experimental	12.59 ± 0.45	2.45 ± 0.11	5.09 ± 0.46	$11.67^{a}\pm1.20$	5.05 ± 0.79	8.82 ± 0.03	92.99 ± 3.24	$0.17^{a}\pm0.02$	$14.19^{a}\pm2.59$
	Control	12.72 ± 0.59	2.43 ± 0.12	5.25 ± 0.35	$12.72^{b}\pm0.86$	4.91 ± 0.61	8.80 ± 0.09	92.18 ± 4.16	$0.21^{b}\pm0.01$	$11.22^{b}\pm2.54$
Total	Experimental	$12.10^{a}\pm0.83$	$2.52^{a}\pm0.17$	$4.80^{a}\pm0.51$	$11.53^{a}\pm1.18$	$4.82^{a}\pm0.62$	$8.81^{a}\pm0.04$	92.37 ± 3.53	$0.17^{a}\pm0.01$	$13.46^{a}\pm2.62$
	Control	$12.69^{b}\pm0.55$	$2.44^{b}\pm0.12$	$5.21^{b}\pm0.31$	$12.67^{b}\pm0.99$	$5.01^{b}\pm0.76$	$8.90^{b}\pm0.10$	93.45 ± 3.95	$0.22^{b}\pm0.02$	$10.58^{b}\pm2.38$

Mean values denoted by different superscripts within laying cycle differ significantly from each other (a, b – $p \leq 0.05$)

According to Renema & Sefton [2004], the addition of organic selenium to poultry feedstuffs increased the number of laid eggs, as well as it improved the quality of egg shell. Authors mentioned above explained this by a positive effect of antioxidants on “calcium metabolism” in bird oviduct. In our study, significant ($p \leq 0.05$) differences between groups in egg shell weight were observed only at the peak of laying cycle. The percentage content of egg shell weight in relation to whole egg weight analysed in the control group was significantly ($p \leq 0.05$) higher (17.04%) than in eggs from the experimental group (15.95%) during the entire laying cycle (Table 1). At the end of the experiment, weight of egg shell in EG increased significantly ($p \leq 0.05$) by about 0.13 g in relation to the results obtained at peak of laying cycle, however percentage content of egg shell weight in relation to the whole egg weight decreased significantly ($p \leq 0.05$) by about 1.74 PP when compared to the beginning of the study. Lower values of percentage content of egg shell weight in relation to whole egg weight observed for eggs from EG was caused by a significant ($p \leq 0.05$) increase in the percentage content of egg white weight in relation to whole egg weight. Similar results was reported by Renema & Sefton [2004], who stated that hens fed fodder supplemented with 0.3 mg/kg of selenium laid eggs with heavier shell (of about 0.76 g) at the end of laying than at the peak of this cycle, whereas percentage content of shell in relation to whole egg weight decreased by about 0.57 PP, as a result of heavier eggs.

The thickness of egg shell measured for the entire laying cycle was higher for eggs from the CG (0.22 mm) than from EG (0.17 mm) (Table 2) and was comparable to findings of other authors [Gonzalez, 1995; Ozbey *et al*., 2004; Bardakcioglu *et al*., 2005]. Despite significantly ($p \leq 0.05$) lower thickness of egg shell from the EG, the addition of selenium and vitamin E significantly ($p \leq 0.05$) increased the strength of egg shell: average values of egg shell strength equaled 13.46 N for EG and 10.58 N for CG (Table 2). Higher strength of egg shell in the experimental group could be caused by better calcium carbonate saturation of the shell, which can improve commercial advantages of eggs, especially during transportation and storage.

CONCLUSIONS

Eggs collected from Japanese quails fed with fodder enriched with organic selenium and vitamin E are characterized by high egg white weight and its high percentage content in relation to the whole egg weight, as well as high egg shell strength.

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WPŁYW DODATKU SELENU ORGANICZNEGO I WITAMINY E NA CECHY FIZYCZNE JAJ PRZEPIÓREK JAPOŃSKICH (*COTURNIX JAPONICA*)

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Celem badań była ocena wpływu dodatku do paszy selenu organicznego i witaminy E na cechy fizyczne jaj przepiórczych ocenianych na przestrzeni całego cyklu nieśnego.

Badania prowadzono na dwóch grupach, po 48 samic w każdej. Od pierwszego dnia życia ptaki z grupy kontrolnej (CG) żywiono paszami podstawowymi, a ptakom z grupy doświadczalnej (EG) dodawano do paszy selen organiczny w ilości 0,3 mg/1 kg paszy (w postaci drożdży selenowych Sel-Plex®, Alltech LTD, USA) i witaminę E (E-50 Adsorbate, Rolimpex S.A.) w ilości 100 mg/1 kg paszy.

Analizie poddano jaja jednodniowe zbierane w trzech okresach cyklu nieśnego: początkowym, szczycie oraz w końcowym. W grupie ocenie poddano 60 jaj, określając masę jaja, skorupy, białka i żółtka oraz ich procentowy udział w masie jaja; wysokość żółtka i białka; szerokość oraz barwę żółtka; grubość i wytrzymałość skorupy, a także obliczono indeks żółtka i jednostki Haugha.

Masa jaja w początkowym okresie nieśności była podobna i wyniosła średnio 9,15 g w grupie doświadczalnej (EG) oraz 8,96 g w grupie kontrolnej (CG). W obu grupach średnia masa jaj między początkowym, a końcowym okresem nieśności uległa ($p \leq 0,05$) podwyższeniu odpowiednio o 1,75 g i 1,97 g. Między grupami w żadnym z badanych okresów nie stwierdzono istotnych różnic w masie jaj.

W całym okresie nieśności masa, procentowy udział żółtka oraz indeks żółtka jaj z CG były wyższe ($p \leq 0,05$) i wynosiły odpowiednio 4,30 g; 44,01% i 5,21% w stosunku do 4,11 g; 40,88% 4,80% jaj z EG. Wysokość białka w CG była wyższa ($p \leq 0,05$) i wynosiła 5,01 mm w porównaniu do 4,82 mm w jajach z EG. Również jaja z CG w analizowanych okresach cyklu charakteryzowała wyższa ($p \leq 0,05$) grubość skorup wynosząca 0,22 mm, w porównaniu do 0,17 mm z EG. Natomiast dodatek selenu i wit. E w EG istotnie ($p \leq 0,05$) wpłynął na masę i udział białka, które wyniosły odpowiednio 4,45 g i 43,18%, w porównaniu do 3,98 g oraz 38,95% jaj z CG oraz zwiększył ($p \leq 0,05$) wytrzymałość skorup 13,46 N dla jaj z EG i 10,58 N jaj z CG.