ИЗСЛЕДВАНЕ НА КАЧЕСТВОТО НА ЧЕРУПКАТА НА ЯЙЦА ОТ ПЪДПЪДЪЦИ (*COTURNIX COTURNIX JAPONICA*) ОТ ПОРОДАТА ФАРАОН, СНЕСЕНИ В ПИКОВАТА ФАЗА НА НОСЛИВОСТТА
RESEARCH REGARDING THE MINERAL SHELL QUALITY OF QUAIL (*COTURNIX COTURNIX JAPONICA*) EGGS FROM PHARAON VARIETY, DEPOSITED AT THE PEAK PHASE OF THE LAYING PERIOD

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Резюме

От 30 японски пъдпъдъка от породата Фараон на възраст 100 дни и с тегло 245 g са събрани 184 яйца, снесени в пиковата фаза на носливостта. Яйцата са претеглени, измерени и счупени за отделяне на черупките от останалото съдържание. Черупките са изсушени и претеглени. За измерване на дебелината на черупката в 3 части (основа, среда, връх) е използван шублер. Чрез изчисление са определени: процент и индекс на черупката, плътност и обем. Определен е и основният химичен състав на черупката, съдържанието на калций, фосфор и магнезий. Получени са следните осреднени стойности: средно тегло на черупката - 0,800 g, представляващо 6,768% от теглото на яйцето. Средната повърхност на черупката е 25,607 cm^2, а индексът на черупката е със стойност 31,251 mg/cm^2. Дебелината на черупката е 153,39 µm в основата на яйцето, 161,39 µm в средата и 172,64 µm при върха, като средно за цялото яйце е 162,476 µm. Плътността на черупката е средно 1,951 g/cm^3, а обемът - 0,416 cm^3. Черупката съдържа 1,87% вода; 98,13% сухо вещество; 87,73% минерали; 10,40% органични вещества, представени от 10,05% протеини и 0,35% въглехидрати. Съдържанието на калций е 1777,5 mg/kg, на фосфор - 90 mg/kg, а на магнезий - 21,5 mg/kg.

Abstract

From 30 Pharaon japanese quails,100 days of age with a weight of 245 g, we collected 184 eggs which were deposited at peak phase of the laying period. These eggs were weighed, measured and broken to separate the mineral shell from the rest of egg content. Eggs shell was dried and weighed. We used a caliper to measure its thickness in 3 areas of the egg (base, middle, top). By calculation we determined: shell proportion and index, density and volume. We also determined the primary chemical composition of shell and its content in calcium, phosphorus and magnesium. We obtained the following results: an average weight of the shell of 0,800 g, representing 6,768% of egg weight. Average shell surface was 25,607 cm^2 and the shell index had a value of 31,251 mg/cm^2. Shell thickness was 153,39 µm, at the bottom of the egg; 161,39 µm, at the middle of the egg; 172,64 µm, at the top of the egg and of 162,476 µm, as an average of entire egg. The shell density of these eggs had an average value of 1,951 g/cm^3 and its volume was 0,416 cm^3. This shell contains 1,87% water; 98,13% DM; 87,73% minerals; 10,40% organic matters, represented by 10,05% proteins and a carbohydrate content, in proportion of 0,35%. The calcium content was 1777,5 mg/kg, the phosphorus content was 90 mg/kg and that of magnesium had a value of 21,5 mg/kg.

Ключови думи: пъдпъдък Фараон, яйце, черупка, химичен състав.
Key words: Pharaon Quail, egg, shell, chemical composition.

INTRODUCTION

Japanese quails (*Cotunix coturnix japonica*) are very prolific birds, their egg production reaching 350 to 400 pcs./year, for the specialized races in this direction. There are some meat breeds, such as Pharaon, which produces about 200 to 220 eggs/year, in addition to meat (Polen, 2007).

Regardless of race, quail eggs have a very valuable chemical composition and an almost complete digestibility (98-99%). They contain proteins and essential amino acids, hydro and liposoluble vitamins, phospholipids and very little cholesterol and triglycerides (Hartmann, 2000). Therefore, these eggs are indicated in the prevention and treatment of many chronic diseases of the cardiovascular and nervous system, digestive system (liver, stomach, pancreas), combat stress, incereasses sexual potency, etc. Chinese natural medicine placed the quail eggs on the 3rd place after viper venom and Ginseng, reckoning it is a real panacea (Vacaru-Opriş, 2000-2007).

Quail eggs have a very thin and fragile mineral shell that breaks very easily and can cause significant loss of production during their handling process. On the quality and integrity of the mineral shell of these eggs depends largely their quality, both for consumption and hatching.

MATERIALS AND METHODS

In these studies we have used biological and non-biological materials and specific working methods (measurements, analyzes, calculations). The biological materials were the birds from Pharaon japanese quail breed and the eggs that these birds produced. The birds that we studied were at the age of 95 to 105 days and had a mean body weight of 245 grams. The eggs were harvested during the peak of the laying period. Quail eggs collected from these birds, a total of 200 pieces, of which 184 were selected, were specifically coloured, with their mineral shell intact and had an average weight of 12 to 13 grams. These eggs were cleaned, individually, weighed and measured with a digital caliper of "Black & Decker" type. Subsequently, eggs were broken and the three components (shell, yolk, egg white/albumen) were individualized. The mineral shell with the external shell membrane has been separated, washed with distilled water, dried in an oven at 65°C for 24 hours (Vacaru-Opriş, 2002), then weighed on a digital balance of "Shimadzu-UX-4200H" type with great precision. A digital caliper was used to measure the thickness of mineral shell of the eggs at their middle, at their thicker end and at the egg's tip (the pointed end). After measuring the shell thickness, we collected some samples from the middle of the egg which were used to determine the number of pores, as it follows: shell fragments were put on the table of a stereomicroscope of "IOR NID-5018-SR 2569-83" type; the pores were found in the microscopic field, then the image has been photographed and electronically processed. For this we used a "Panasonic – Lumix-DMC" digital camera and "Digimizer" image processing software.

To calculate the mineral shell surface we used the following mathematical formulas:

(1) S=(3,155-0,0136xL+0,0115*B)*L*B, (Narushin, 2005), where: S=egg/shell surface (mm^2); L=longitudinal diameter of egg (mm); B=transversal diameter of egg (mm).

To calculate the proportion of mineral shell (Pms) we used:

(2) $Pms = \frac{Msw.100}{Tew}$, where: Msw=mineral shell weight (grams); Tew=Total egg weight (grams).

To calculate the mineral shell index (Ims) we used the following relation:

(3) $Ims = \frac{Msw}{Sms}$, where: Sms=surface of mineral shell (cm^2).

To calculate the volume of eggs we used a mathematical relation (Narushin, 2005):

(4) $V=(0,6057-0,0018*B)*L*B^2$, where: L and B have the same significance as (1).

To calculate the mineral shell density we used the following:

(5) $\rho = \frac{10}{Mst} Ims$, where: ρ=mineral shell density (g/cm^3); Mst=mineral shell thickness (mm); Ims=index of mineral shell.

The volume of mineral shell (Vms) has been determined by:

(6) $Vms = \frac{Msw}{\rho}$, where: Msw=mineral shell weight (g); ρ=mineral shell density (g/cm^3).

After these operations of weighing and measuring have been done, the 184 egg shells were dried and grounded and then we determined the primary chemical composition (water, raw minerals and protein)(Prelipcean, 2010; Prelipcean, 2011; Teuşan, 2009) and their content of calcium, phosphorus and magnesium. For these measurements we used the following methods: drying in an oven at 65°C, calcination method, Kjeldahl-Velp method, atomic absorption spectrometry methods.

All data obtained were tabulated as gross data and then statistically: mean ($\bar{x}$), standard error of the mean ($s\bar{x}$), standard deviation (s), variance (s^2), and the coefficient of variation (v%)(Sandu, 1995). To achieve these statistical calculations we used Instat software.

RESULTS AND DISCUSSION

The results obtained from these investigations can be grouped into two categories, namely: a category that includes data on weight, thickness, density pores, surface and volume of the mineral shell eggs studied and a second category which refers to primary and secondary chemical composion of the mineral shell. Both categories of results define the quality of these eggs mineral shell.

Thus, the average weight of these 184 egg shells we studied was 0,800±0,0074 grams (v=12,49%), which represents (as average) 6,768±0,054% of the total weight of the eggs (v=10,79%) (table 1). The surface of mineral shell of these quail eggs ranged between 21,2014 cm^2 and 30,3374 cm^2, the statistical average value of the 184 eggs was of 25,607±0,121 cm^2 (v=6,41%) (table1). Regarding the mineral shell index, it had average values of

Таблица 1. Тегло, повърхност и дебелина на черупката на яйца от пъдпъдъци, порода Фараон, снесени в пика на яйценосния период

Table 1. The weight, surface and thickness of quail eggs mineral shell from Pharaon breed, deposited at the peak of the laying period

Specification Показатели		MU	N	Statistical indicators Статистически параметри			Variation limits Граници на варириане	
				$\bar{x}\pm s\bar{x}$	s	V%	minimum	maximum
Mineral shell weight Тегло на черупката		g	184	0,800±0,0074	0,1000	12,49	0,552	1,092
Mineral shell proportion from total egg weight Относителен дял на черупката от масата на яйцето		%	184	6,768±0,054	0,7304	10,79	4,79342	8,8425
Mineral shell surface* Повърхност на черупката		cm^2	184	25,607±0,121	1,64065	6,41	21,2014	30,3374
Index of mineral shell Индекс на черупката		mg/cm^2	184	31,251±0,248	3,3586	10,75	22,4501	40,2237
Mineral shell thickness Дебелина на черупката	At base of egg В основата на яйцето	μ	184	153,388±1,689	22,9078	14,93	96,667	213,333
	At top of egg На върха на яйцето	μ	184	172,64±2,140	29,030	16,80	103,333	256,667
	At middle of egg В средата на яйцето	μ	184	161,395±1,818	24,6589	15,28	96,667	230,000
	For whole egg Средно за яйцето	μ	184	162,476±1,766	23,9617	14,75	100,00	222,222

*Mineral shell surface was calculated after Narushin mathematical relation

Повърхността на черупката е определена по метода на математическите зависимости на Narushin (2005)

31,251±0,248 and an average variation of v=10,75% (table 1). This index, which represents the weight of the egg shell surface, depends on the thickness, density and number of pores that exist in this shell. Thus, the average thickness of the egg mineral shells we studied was: of 153,388±1,689 μm, at the thicker end (base) of the egg; of 172,64±2,41 μm, at the pointed end (tip) of the egg; of 161,395±1,818 μm, at the middle area of the egg and of 162,476±1,766 μm, as a mean of the while egg (table 1). The variability of quail egg shell thickness was quite pronounced (v=14,93%; 16,80%; 15,28%; 14,75%) (table 1). It is important to notice and comment the fact that the shell thickness was with 12,55% higher at the peak area of the egg, but compared to the top area of the egg, it is thinner by 6,51%. As an average of the whole egg, the mineral shell has a very close thickness value (162,476 μm) of the middle area of the egg (table 1).

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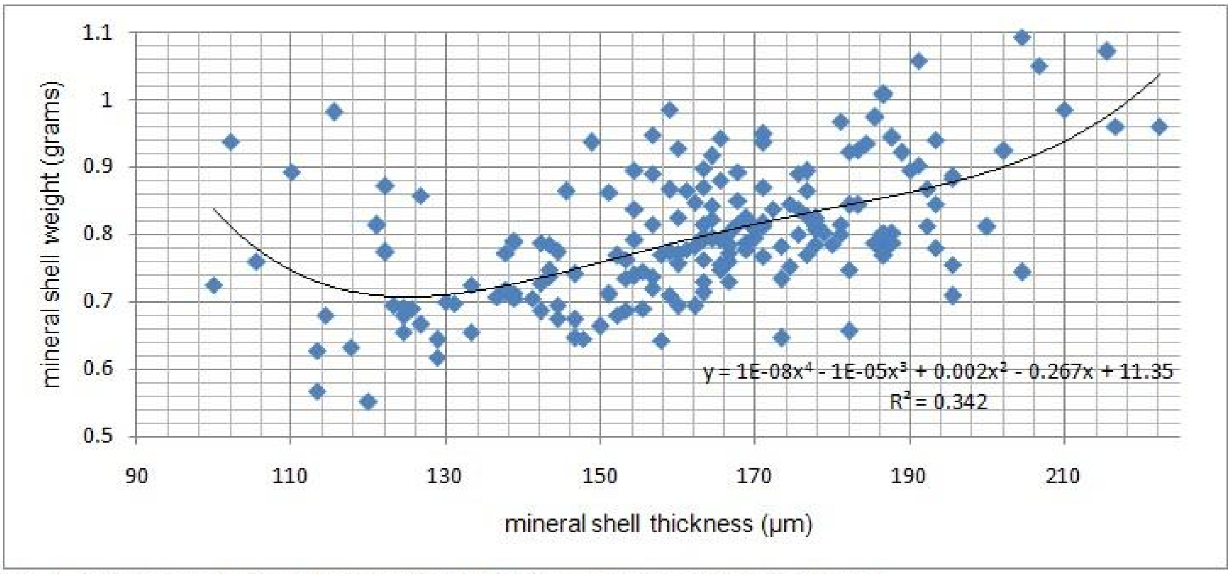

Fig. 1. Correlations between the weight and thickness of quail eggs mineral shell

weight increases, but not linearly, whereas other foctors are involved suck as shell density and the number of pores (fig. 1). Regarding the eggs mineral shell density, it turned out to be quite variable for the 184 eggs we studied so that the specific coefficient has a value of v=13,93% and the statistical average value for this data is 1,9509±0,020 g/cm^3 (table 2). The eggs mineral shell density is almost double (with 88,89% higher) than the whole eggs density (1,0328 g/cm^3) (Prelipcean, 2012a; Prelipcean, 2012b), due to its very low water content and high in minerals. The

Таблица 2. Плътност, обем и брой на порите в черупката на яйца от пъдпъдъци, порода Фараон, снесени в пика на яйценосния период

Table 2. The density, volume and number of pores of quail eggs mineral shell from Pharaon breed, deposited at the peak of the laying period

Specification Показатели		MU	N	Statistical indicators Статистически параметри			Variation limits Граници на вариране	
				$\bar{x}$±s$\bar{x}$	s	V%	minimum	maximum
Mineral shell density Плътност на черупката		g/cm^3	184	1,9509±0,020	0,271676	13,93	1,49227	3,19037
Mineral shell volume Обем на черупката	Absolute values Абсолютна стойност	cm^3	184	0,4162±0,005	0,06835	16,42	0,2460,	0,6266
	Relative values reported at whole egg Относително спрямо общия обем на яйцето	%	184	3,379±0,0376	0,5099	15,09	2,000	4,800
Whole egg volume* Обем на яйцето*		cm^3	184	12,3585±0,086	1,16839	9,45	9,2392	15,8456
Number of mineral shell pores** Брой на порите в черупката**		pores/cm^2	77	134,06±3,03	26,6286	19,86	91,64	199,84

*volume was calculated after Narushin mathematical relation; **The number of pores was determined for the middle area of quail egg mineral shells
*обемът е определен по метода на математическите зависимости на Narushin (2005), **Броят на порите в черупката е определен в средната зона на яйцето

Таблица 3. Химичен състав на черупката на яйца от пъдпъдъци, порода Фараон, снесени в пика на яйценосния период

Table 3. The primary chemical composition of quail eggs mineral shell from Pharaon breed, deposited at the peak of the laying period

Specification Показатели		MU	N	Statistical indicators Статистически параметри			Variation limits Граници на вариране	
				$\bar{x}\pm s\bar{x}$	s	V%	minimum	maximum
Water content Вода		%	5	1,872±0,006	0,01304	0,70	1,86	1,89
Dry substance content Сухо вещество		%	5	98,128±0,006	0,01303	0,01	98,11	98,14
Mineral substances Content Минерални вещества	from mineral shell от черупката	%	5	87,728±0,059	0,13013	0,15	87,55	87,90
	from DS*of mineral shell от сухото вещество на черупката	%	5	89,586±0,204	0,45654	0,51	89,22	90,37
Organic substances content Органични вещества	from mineral shell от черупката	%	5	10,40±0,057	0,12747	1,23	10,24	10,58
	from DS*of mineral shell от сухото вещество на черупката	%	5	10,598±0,058	0,13065	1,23	10,43	10,78
Protein content Протеин	from mineral shell от черупката	%	5	10,048±0,019	0,04324	0,43	10,00	10,10
	from DS*of mineral shell от сухото вещество на черупката	%	5	10,238±0,019	0,04324	0,42	10,19	10,29
Carbohydrate content Въглехидрати	from mineral shell от черупката	%	5	0,352±0,074	0,16574	47,08	0,16	0,58
	from DS*of mineral shell от сухото вещество на черупката	%	5	0,36±0,075	0,16867	46,85	0,16	0,59

*DS=dry substance / Сухо вещество

density of quail eggs mineral shell id influenced by the number of pores in it. Our measurements showed that in the middle area of the egg, the number of pores is, in average, 134,06±3,03/cm^2 of shell (v=19,86%) (table 2) with rather large variations in the 77 eggs under study for this character. Objective reasons stoped us from determining the diameter of these pores, aspect which is to be considered in future studies.

In terms of volume of these mineral shell, the data we obtained show that the mineral shell is the lower component in terms of volume and weight. Thus, the statistical mean for the 184 eggs studied is 0,4162±0,005 cm^3 (v=16,42%), which represents only 3,379±0,0376% of the whole egg volume (12,3585±0,086 cm^3) (table 2).

Regarding the primary chemical composition of the eggs mineral shell, this indicated a very low water content ie 1,872±0,006% (v=0,70%) and a very high dry matter and mineral substances content, as it is natural. Thus the average dry matter content of the shell is 98,128±0,006% (v=0,01%). The predominant mineral part of the shell, which is 87,728±0,059% of the shell itself and 89,586±0,204% of the dry weight of the shell (table 3).

The organic substances from the quail eggs mineral shell represents 10,40±0,057% (10,598±0,0585 of DS) (v=1,23%) and are composed of proteins (especially collagen) and carbohydrates. Shell protein content of quail eggs has an average 10,048±0,019% (10,238±0,019% of DS) (v=0,42-0,43%), while the sugars (carbohydrates) were

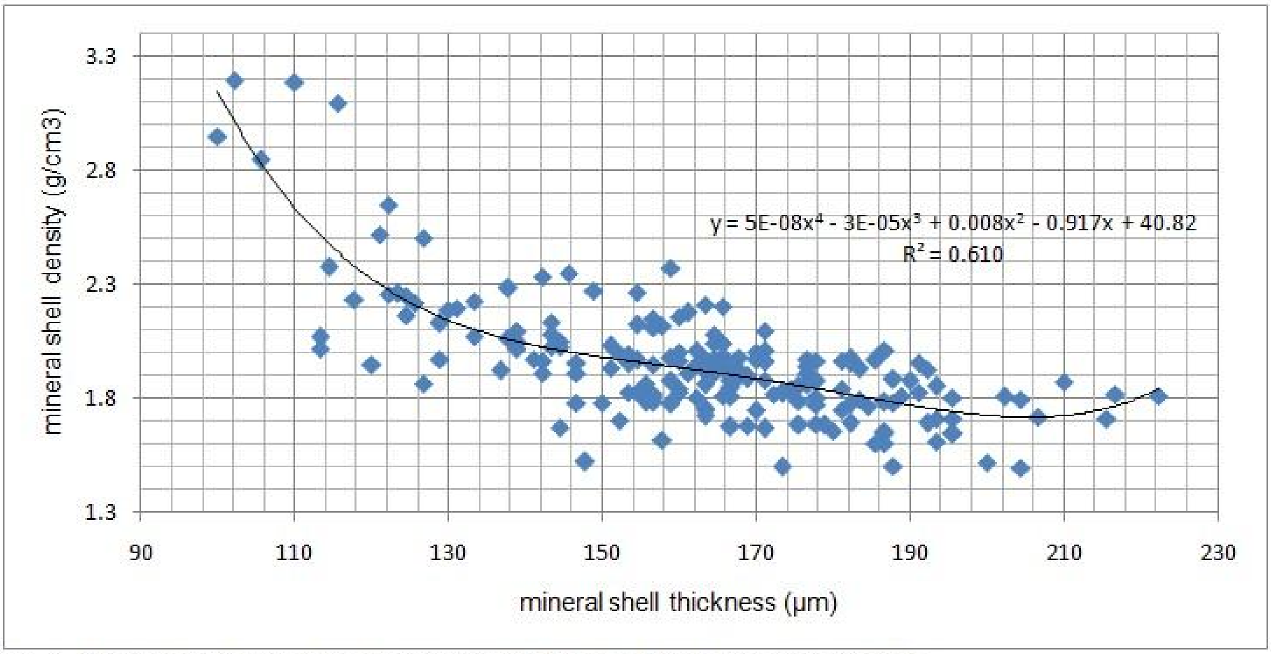

Fig. 2. Correlations between the density and thickness of quail eggs mineral shell

Таблица 4. Съдържание на калций, фосфор и магнезий в черупката на яйца от пъдпъдъци, порода Фараон, снесени в пика на яйценосния период

Table 4. Calcium, phosphorus and magnesium content of quail eggs mineral shell from Pharaon breed, deposited at the peak of the laying period

Specification Показатели		MU	N	Statistical indicators Статистически параметри			Variation limits Граници на вариране	
				$\bar{x}\pm s\bar{x}$	s	V%	minimum	maximum
Calcium Калций	from mineral shell от черупката	ppm	6	1777,5±21,943	53,75035	3,02	1674,00	1821,00
	from DS*of mineral shell от сухото вещество на черупката	ppm	6	1811,41±22,40	54,8623	3,03	1705,726	1855,739
Phosphorus Фосфор	from mineral shell от черупката	ppm	6	86,333±1,764	4,3205	5,00	81,00	92,00
	from DS*of mineral shell от сухото вещество на черупката	ppm	6	87,98±1,80	4,4072	5,01	82,535	93,772
Magnesium Магнезий	from mineral shell от черупката	ppm	6	21,45±0,45	1,111305	5,18	20,00	22,70
	from DS*of mineral shell от сухото вещество на черупката	ppm	6	21,859±0,46	1,13296	5,18	20,379	23,135

*DS=dry substance / сухо вещество

0,352±0,074% (0,36±0,075% of DS) (table 3). For deeper knowledge of the chemical composition of the quail eggs mineral shell, we determined the content in calcium, phosphorus and magnesium , which are the most important minerals that contribute to shell formation and strength. Calcium content was, on average, 1777,5±21,943 mg/kg (ppm)(v=3,02%) of the shell itself and 1811,41±22,4 mg/kg of shell dry matter (table 4). Phosphorus content had an average value of 86,333±1,764 mg/kg of the shell itself and 87,98±1,8 mg/kg of shell DS (v=5,0-5,01%) (table 4). Regarding the magnesium content, it was 21,45±0,45 mg/kg of the shell itself and 21,859±0,46 mg/kg of shell DS (v=5,18%) (table 4).

CONCLUSIONS

1. The mineral shell of Pharaon variety quail eggs that were collected at the peak phase of the laying period has an average weight of 0,800 grams, which represents 6,77% of the total egg weight.
2. The quail egg mineral shell index (weight of surface unit) has an average value of 31,251, while its surface is 25,607 cm^2.
3. Pharaon quail eggs shell thickness is: 153,381 µm, at the thick end; 161,395 µm, in the middle area; 172,64 µm at he sharp end and 162,476 µm, as average of the 3 measured places.
4. Shell density and volume had mean values of 1,9509 g/cm^3, respectively 0,4162 cm^3, the latest representing 3,38% of whole egg volume (12,358 cm^3).
5. The number of pores in the middle area of the eggs is 134/cm^2.
6. The mineral shell of Pharaon quail eggs contains: 1,87% water; 98,13% DS; 87,73% mineral substances; 10,40% organic matter; 10,05% proteins and 0,35% carbohydrates.
7. The mineral shell of these eggs also contains: 1777,5 mg/kg calcium (ppm); 86,333 mg/kg phosphorus and 21,45 mg/kg magnesium.

REFERENCES

Hartmann, C., E. Strandberg, L. Razdhmer, K. Johfansson, 2000. Egg composition and material effects on hatchling weight, XXI World's Poultry Congress, Montreal, 20-24 august, Canada.

Narushin, V.G., 2005. Egg geometry calculation using the measurements of length and breadth, Poultry Science, p. 84, 482-484.

Polen, T., V. Herman, 2007. Sfaturi utile despre creşterea prepeliţelor, Col. Rev. Ferma, Editura WaldPress, Timişoara, 50-60.

Prelipcean (Teuşan), Anca, 2010. Contribution to the knowledge of hatching quail eggs quality and of embrionic development of this species, phD dessertation, U.S.A.M.V. Iaşi, România, 30 septembrie, 96-105.

Prelipcean (Teuşan), Anca, A. Al. Prelipcean, V. Teuşan, 2011. Research regarding the structure, chemical composition and caloricity of quail eggs, deposited at the beginning phase laying, Lucr. Şiinţ. U.S.A.M.V. Iaşi, Seria Med.- Vet., vol. 54, nr.3-4, 135-145; 174-185.

Prelipcean, Anca, 2012. The structure and some synthetic quality indices of Pharaon quail eggs, deposited at the peak phase of the laying period, Lucr. Şiinţ. U.S.A.M.V. Iaşi, România, Seria Zootehnie, vol. 56 (17), 232-239.

Prelipcean, Anca, 2012. Cercetări privind morfologia ouălor de prepeliţă din rasa Faraon produse în faza de vârf a perioadei de ouat, Lucr. Şiinţ. U.S.A.M.V. Iaşi, România, Seria Med.-Vet., vol. 55 (1-2), 94-101.

Sandu, Gh., 1995. Metode experimentale în zootehnie, Editura Coral-Sanivet, Bucureşti, 34-40

Teuşan, Anca, Teuşan V., A.Al. Prelipcean, 2009. Studiu privind o serie de indicatori fizici de calitate ai ouălor de prepeliţă japoneză depuse în faza de platou de ouat, Lucr. Şiinţ. U.S.A.M.V. Iaşi, România, Seria Zootehnie, vol. 52 (14), 450-455.

Vacaru-Opriş I. şi col., 2000-2007. Tratat de avicultură, Editura Ceres, Bucureşti, vol. I, 293-295.

Vacaru-Opriş I. şi col., 2002. Tratat de avicultură, Editura Ceres, Bucureşti, vol.II, 48-57.

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