Egg productivity and egg quality estimation and evaluation of two breeds of Japanese quails (Coturnix japonica)

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Abstract. *The goal of this investigation is to characterize egg production and to estimate , evaluate and compare egg quality of two breeds, grown at the Department of Poultry Science – meat type Pharaoh and combined type Manchurian gold.*
The result of the study established that the genetic ability for egg production of the breed Manchurian gold is higher compared to the breed Pharaoh. The laying intensity of the breed Manchurian gold is higher (P≤0,001), and for the controlled period up to the age of 150 days the percentage of culled non-standard eggs for this breed is lower 1,97±0,41 vs 3,2±0,55 for the breed Pharaoh. The highest percentage of non-standard eggs for both breeds is between 2nd and 9th production week (2,57±0,80 for the breed Manchurian gold vs 4,60±0,98 for the breed Pharaoh, as 30 – 57% of these eggs are with double yolk). The complex estimation of production showed that the total egg mass obtained from an average layer in the control period of 150 days is higher by 6,1% for the Manchurian gold compared to breed Pharaoh - 1,212 kg vs 1,142 kg.
Egg quality of laid eggs from the Manchurian gold breed is higher compared to that of the Pharaoh breed. Values of the albumen index and internal quality units (IQU) are by 7,9% higher on average (P≤0,05 about index and P≤0,001 about IQU) compared to those for the Pharaoh breed. The shell of the Manchurian Golden quail eggs was stronger by 4.6% compared to the shells of the Pharaoh quail eggs, with statistically significant difference at the beginning of the laying period (P≤0.05).

Key words: Japanese quails, egg production, egg quality.

Introduction

In Japanese quails egg weight is largely dependent on the production type of birds. In the layer type, it is 8-10 g, in the combined type - 10-11 g, and for the broiler type - 12-16 g (Afanasiev, 1994). Egg weight changes most extensively within the period from the beginning of laying to peak laying, when it increases by about 14% on the average (Genchev et al., 1999). The eggs of Japanese quails have shape index of 78-81%. According to data by Genchev and Alexieva (1998), this egg trait, similarly to egg weight, changes to the greatest extent from the time of laying to the moment of peak laying. The egg shell colour varies from dark brown to white, often with a bluish ground. Eggs are mottled with multiple black or bluish spots of variable size and shape. The spots are formed by the pigments ovoporphyrin and biliverdin during the last 3.5 hours of the egg's stay in the uterus (Panda and Singh, 1990).

Of egg components albumen is the most important. It is composed of four layers of different density – chalaziferous, inner thin, outer thick and outer thin. Of them, viscosity and shape of the outer thick layer are evaluated. The albumen index and Haugh units (HU) are used as an objective criteria for egg albumen quality. According to some authors, HU could not provide an exact evaluation of albumen quality for quail eggs. On the basis of the classical equation of Haugh, Kondaiah et al. (cited from Panda and Singh, 1990) suggested a modified equation, giving the so-called internal quality units (IQU). According to Imai et al., IQU in fresh quail eggs is about 62 and it is a better parameter of egg quality (Imai et al., 1986).

Egg yolk consists of 5-6 alternating pairs of light and dark rings. For quail eggs, its diameter is 25 mm on average and its shape is almost spherical. Depending on the content of carotenoids and xanthophylls, its colour varies from pale yellow to dark orange. The relative proportion of yolk is 31-37% of quail egg weight (Panda and Singh, 1990; Genchev et al., 1999).

The purpose of the present study was to perform an evaluation of egg productivity and to compare the quality of eggs laid by two breeds of Japanese quails, reared in the Poultry Breeding Section of the Faculty of Agriculture: the meat-type Pharaoh breed and the all-purpose Manchurian Golden breed.

Material and methods

The experiments on productivity control and egg quality evaluation began from the start of laying and lasted until the 150th day of age of layers. By the end of the first, the beginning of the 3rd and the middle of the 4th productive month (corresponding to

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beginning of laying, peak laying and post-peak laying, respectively), all eggs laid within 24 hours from both breeds were collected for quality analysis.

During the experiment, the following parameters were controlled: sexual maturity, laying intensity, exterior of eggs – normal or abnormal (with various deformities, double-yolked or soft shells), as well as egg quaality traits such as egg weight, shape index, yolk index, albumen index, Haugh units, internal quality units (IQU) and shell strength.

Egg mass was controlled by scale *Chirana 02*, at precision of 0,1g. Shape index (SI) was determined by the Romanoff's formula: $SI=d/D*100$, where d is the minor axis, D – the major axis of the egg (Romanoff and Romanoff, 1959). Yolk index (YI) was determined by the classical equation $YI=h/D*100$, where h is yolk height and D – yolk diameter. The albumen index (AI) was calculated by means of a similar formula: AI=h/(0.5*(d+D))*100, where h is the height of thick albumen at the boundary with the yolk; D and d – the large and small diameters of albumen, respectively (Romanoff and Romanoff, 1959).

Haugh units were calculated as per $HU=100*\log(h+7.57-1.7*W^{0.37})$, where h is the height of thick albumen at the boundary with the yolk; W – egg weight. IQU was calculated according to the equation of Kondaiah et al. (cited from Panda and Singh, 1990): $IQU=100*\log(h+4.18-0.8989*W^{0.6674})$.

Shell strength at break (*kg*) was assessed with an electronic penetrometre ***AC-4*** with a specially designed device.

The shell area (cm^2) and the egg volume were calculated by the formulas of Ushakov et al. (1996) S=d*D*γ, where: d was the minor axis; D – the major axis of the egg. The value of γ was obtained according to the equation:

The egg volume was determined as: $V=\pi/\gamma*d^2*D$.

The results were processed by routine methods of statistical analysis included in the *MS Excel 2003* package. Data were analyzed by two-factor statistical analysis as described by Merkurieva (1970).

$$\gamma = \frac{1}{2}\pi * \left[\frac{d}{D} + \frac{\arcsin\sqrt{1-\left(\frac{d}{D}\right)^2}}{\sqrt{1-\left(\frac{d}{D}\right)^2}} \right]$$

Results

The rate of egg productivity increase during the first productive month in both breeds was similar (Fig. 1). Almost within the entire controlled period the laying intensity of Manchurian Golden layers was higher and the relative proportion of non-standard eggs – lower, compared to the Pharaoh breed (1.97±0.41 % vs 3.20±0.55 %, respectively; Fig 2). Between the 2nd and the 9th productive weeks, the percentage of culled non-standard eggs in Manchurian Golden quails was 2.57±0.80 vs 4.60±0.98 in Pharaoh quails, but the difference was not statistically significant. The main part of culled eggs within this period was due to those with double yolks (34.0±8.1% in Manchurian layer eggs and 28.3±4.9% in Pharaoh layer eggs; Fig. 3).

The processing of results for laying intensity for longer periods allows to distinguish the real peak in laying capacity that was during the 3rd productive month in both studied breeds (Table 1).

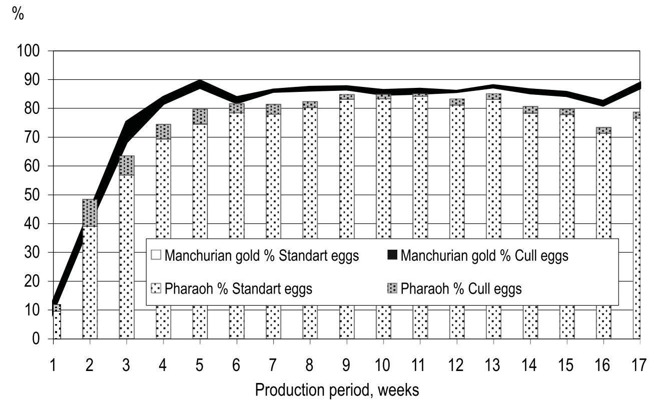

Figure 1. Intensity of lay, %

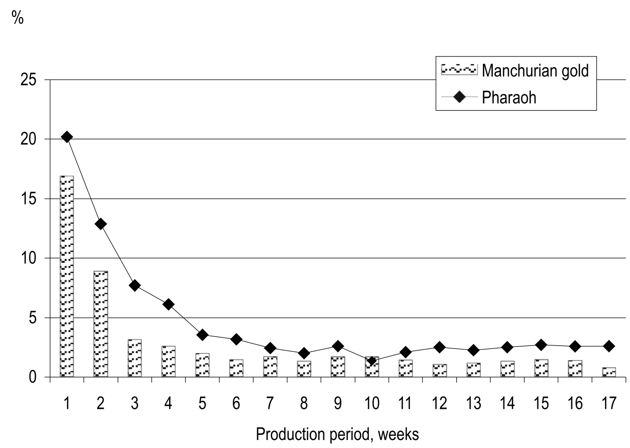

Figure 2. Culled eggs, %

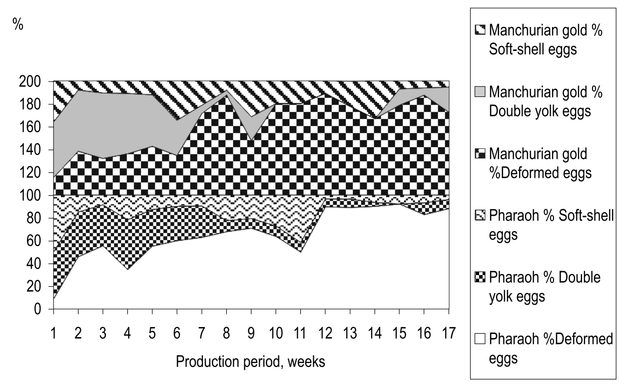

Figure 3. Distribution of cull, %

During this productive month, the least difference between breeds with regard to laying intensity was recorded – 4.8%. As a whole, during the experimental period, Manchurian Golden quails gave 95.63 eggs per layer vs 87.24 eggs per one Pharaoh layer, but the

Table 1. Percent of obtained standard eggs and egg mass, g

Production month	Pharaoh breed		Manchurian gold breed	
	% standard eggs	Egg mass g	% standard eggs	Egg mass g
I	50,27±2,27c	12,83±0,096c	67,78±1,94d	11,86±0,087d
II	79,65±1,34a	13,13±0,086c	84,31±1,26b	12,51±0,057d
III	81,72±1,63	13,19±0,082	85,63±1,37	13,00±0,064
IV	74,63±2,08c	13,17±0,103	84,14±1,95d	13,00±0,062
Average for control period	73,31±5,30	13,13±0,049c	80,36±3,26	12,67±0,035d

Note: Values within rows with different letters differ significantly: a,b ($P<0.05$); c,d ($P<0.001$)

difference was insignificant. For this period, one Manchurian Golden quail layer gave a total of 1.212 kg eggs vs 1.142 kg from one Pharaoh quail layer.

Table 2 presents the parameters that characterize egg quality. The comparison of egg shapes showed that shape indices in both breeds were similar, without any trends of changes according to the productive cycle stage.

With regard to eggshell strength, Manchurian Golden quails exhibited better parameters. On average, the strength to break of shells in the eggs of this breed was superior to that in Pharaoh eggshells: 1.74±0.03 kg/cm^2 vs 1.66±0.03 kg/cm^2, respectively. Comparing the differences in this trait according to the productive cycle stage, it was shown that they were statistically significant only in the period at the beginning of laying ($P\leq0.05$).

There were no considerable differences between both breeds related to egg volume and shell area. In general, their changes with time followed the alterations in egg weight. The area-to-weight ratio in both breeds varied within a narrow range: 2.0-2.07.

Quality parameters of egg content are presented in Table 3. The albumen index in Manchurian Golden quail eggs were higher (0.123±0.002) than those in Pharaoh eggs (0.114±0.003) at $P\leq 0.05$. The IQU, as a complex trait of egg quality, exhibited higher score in Manchurian Golden quails with statistically significant difference ($P\leq0.001$).

With regard to yolk quality, there were no differences between breeds, nor any differences related to the productive cycle stage. Yolk index ranged between 0.457 and 0.493.

Discussion

The age when Japanese quail layers from both studied breeds began laying eggs was 3839 days. Our two quail populations reached maturity by 1012 days on average compared to data reported by others (4852 days) for quails from the all-purpose (Yalmaz Dikmen and Ipek**,** 2006) and meat production (Milvielle, 2002) types.

The curve of egg laying showed that in the period at beginning of laying, the difference between breeds was more obvious between the 3^{rd} and 5^{th} production weeks, where it ranged between 14.8 - 17.1%. The higher intensity of laying in Manchurian Golden quails (by about 7.8%) was anticipated, taking into consideration the productive type of the breed.

The analysis of eggs culled during the period of the study showed that throughout the first 67 weeks of egg laying, double-yolk eggs prevailed (30-57% from all non-standard ones). After the 6^{th} productive week in Manchurian Golden quails and after the 7^{th} in Pharaoh quails, the functions of the ovary and the oviduct were synchronized and as a result, the share of double-yolk eggs decreased under 10%. This is the period when layers' growth ended and the laying intensity was high – over 80%. Such intensity of laying is proper for Manchurian Golden quail layers after the 3^{rd} productive week, whereas for Pharaoh layers it occurred between the 6^{th} and 14^{th} productive weeks. Between the 2^{nd} and the 9^{th} productive weeks the percentage of culled non-standard eggs in Manchurian Golden breed was almost twice lower compared to the Pharaoh breed, similar to data reported by Milvielle (2002) about non-standard eggs laid by quails from the heavy production type.

During the controlled period, Manchurian Golden quails gave 9.6% more eggs compared to Pharaoh quails. To summarize, it could be stated that the total egg weight per one Manchurian Golden quail layer was 6.1% higher compared to that obtained from one Pharaoh layer.

The analysis of data about productivity demonstrates the superiority of genetic potential for egg production of Manchurian Golden quails. The average weight of eggs laid by Manchurian Golden birds was above the values reported by others (Afanasiev, 1991; Aggoor et al., 2006; Ylmaz Dikmen and Ipek, 2006) for birds from the same productive type and therefore allowed us to assume that this breed could be successfully used in the industrial production of eggs from Japanese quails.

More distinct inter-breed differences were observed in shell strength, with Manchurian Golden quails showing better parameters. For the period of the study, eggs laid by Manchurian Golden layers showed on average better resistance to compression by 4.6% compared to the eggshells of the Pharaoh breed.

The ratio of egg volume to egg weight suggested that in the beginning of the productive period, there was a larger egg volume per 1 g of weight in both breeds. The reduction of the volume to weight ratio with age is related to the altered ration of albumen to yolk on one hand, but according to Genchev (1997), it could be interpreted in a broader sense as being connected to the regulation of water balance during the period of incubation.

The lower area to weight ratios in quail eggs as compared to those recommended by Tsarenko (1988) in gallinaceous birds are due to the relatively thinner shell. Proven that the average thickness of quail eggs was 0.21-0.23 mm (Genchev et al., 1999; Aggoor et al., 2006; Ylmaz Dikmen and Ipek, 2006), the relative proportion of shell from the total egg weight varies from 8.9-9.7% (Genchev and Alexieva, 1999) to 10.8-10.9% (Aggoor et al., 2006).

Table2. Outside characteristics of eggs.

Indications	Phase of production cycle						Average values	
	Pharaoh breed			Manchurian gold breed			Pharaoh breed	Manchurian gold breed
	Start of lay	Peak of lay	After peak of lay	Start of lay	Peak of lay	After peak of lay		
	n=157	n=78	n=52	n=129	n=63	n=55	n=287	n=247
Mass of investigated eggs	13,10±0,10c,a	13,60±0,14d	13,57±0,19d,b	12,69±0,08c	12,93±0,14c,d	13,20±0,15d	13,32±0,08e	12,86±0,06f
Shape index, %	77,6±0,29	77,8±0,61	77,9±0,45	77,7±0,27	77,2±0,42	77,4±0,40	77,7±0,24	77,5±0,20
Strength of shell kg/cm^2	1,51±0,11	1,62±0,05	1,70±0,04	1,77±0,05	1,74±0,05	1,71±0,05	1,658±0,030	1,739±0,031
Egg volume ml	26,16±0,20	26,94±0,38	26,65±0,36	25,56±0,17	26,00±0,32	26,00±0,32	26,46±0,17c	25,77±0,14d
Surface of the shell, cm^2	26.63±0.14	27.16±0.27	26.97±0.24	26.23±0.11	26.51±0.22	26.51±0.22	26.84±0.11c	26.37±0.09d
Ratio: volume: mass, ml/g	1.999±0.008a	1.979±0.018a,b	1.967±0.009b	2.014±0.005e	2.010±0.006e	1.969±0.005f	1.99±0.007	2.00±0.003
Ratio: Surface: mass, cm^2/g	2,04±0,01	2,00±0,01	2,00±0,01	2,07±0,01e	2,06±0,01e	2,01±0,01f	2,02±0,006e	2,05±0,004f
Ratio: volume: surface, ml/g	0,980±0,003	0,988±0,006	0,986±0,005	0,973±0,002	0,979±0,004	0,979±0,004	13,32±0,08a	0,98±0,002b

Note: Values within breeding group with different letters differ significantly: a,b (P<0.05); c,d (P<0.01); e.f (P<0.01).

Table 3. Quality characteristics of egg content

	Phase of production cycle						Average values	
	Pharaoh breed			Manchurian gold breed			Pharaoh breed	Manchurian gold breed
Indications	Start of lay	Peak of lay	After peak of lay	Start of lay	Peak of lay	After peak of lay		
	n=55	n=37	n=27	n=41	n=31	n=29	n=119	n=101
Albumen index	0,113±0,004	0,116±0,005	0,112±0,005	0,129±0,004a	0,121±0,006a,b	0,115±0,004b	0,114±0,003a	0,123±0,002b
Haugh units	88,25±0,87	89,82±1,04	89,58±1,23	91,79±0,69c	90,90±1,00c,d	88,58±0,89d	89,04±0,58	90,60±0,5
IQU	54,46±1,99	57,62±2,22	57,18±2,72	63,20±1,45c	60,94±2,14c,d	56,22±2,00d	56,06±1,29c	60,50±1,07d
Yolk index	0,475±0,005	0,478±0,006	0,459±0,007	0,484±0,005c	0,493±0,006c,e	0,457±0,007d,f	0,473±0,003	0,479±0,004

Note: Values within rows with different letters differ significantly: a,b (P<0.05); c,d (P<0.01); e.f (P<0.01).

The albumen index in Manchurian Golden quail eggs was by 7.9% higher on average compared to Pharaoh quail eggs. The same difference was established for IQU. The comparable differences between both breeds with regard to albumen index and IQU scores could be explained by the fact that IQU percentages of 73.3-86.3% were determined by albumen quality. The influence of the breed on the IQU trait was considerably lower – about 6.4%, with slightly better effect in the Pharaoh breed. Haugh units in both breeds were similar and between 88.25-91.79, our values being by 12% higher with those reported by Aggoor et al. (2006) – 78.6-82 HU.

Conclusions

The results of investigation show that during the controlled period up to 150 days, the laying intensity of Manchurian Golden quails is higher than the average for the Pharaoh breed with 9,6% ($p<0.001$). As a result of this, the total egg mass obtained from an average layer is 6.1% higher. During the controlled period the relative part of culled non-standard eggs from Manchurian Golden quails was lower 1.97% vs 3.2% from the Pharaoh breed. The percentage of non-standard eggs was the highest between the 2nd and the 9th productive weeks.

The albumen index and IQU in Manchurian Golden quail eggs were on average by 7.9% higher compared to eggs from Pharaoh quails. The differences were statistically significant at $P\leq0.05$ for the albumen index and $P\leq0.001$ for IQU.

The shell of Manchurian Golden quail eggs was stronger by 4.6% compared to shells of Pharaoh quail eggs with statistically significant difference at the beginning of the laying period ($P\leq0.05$).

The presented results demonstrate the superiority of the genetic potential of Manchurian Golden quails with regard to egg production and allow us to recommend this breed for industrial production of Japanese quail eggs.

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