**Revista Brasileira de Zootecnia**

ISSN 1806-9290
www.sbz.org.br

**R. Bras. Zootec., v.41, n.9, p.2079-2084, 2012**

# Technological quality of eggs in relation to the age of laying hens and Japanese quails

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**ABSTRACT** - This investigation was carried out to evaluate certain egg quality characteristics of ISA Brown laying hens and Japanese quails (*Coturnix coturnix japonica*) in relation to their age. One hundred forty-four brown-egg ISA Brown laying hens and one hundred female quails were used in the study. A total of 1,678 eggs of laying hens and 2,060 eggs of Japanese quails were used during the experiment. The eggs for technological values were collected during two consecutive days in a 4-week period when the laying hens were from 20 to 60 weeks of age and the quails were from nine to 49 weeks of age. The results show that egg weight was affected by the age of the hens and quails (overall means 61.13 g and 12.52 g, respectively). Despite frequens fluctuations, as the age of the laying hens and quails increased, the yolk index and yolk proportion increased as well, while the albumen index, eggshell strength and shell thickness decreased. The increasing age of the hens also led to a decrease in egg shape index and eggshell proportion, but these parameters increased in the quails. A significantly higher proportion of albumen was found in the hens than in the quails, but of worse quality than in the quails as expressed by Haugh units score. The egg from ISA Brown hens had a darker yolk color than those from Japanese quails (5.90 vs. 4.87 in the La Roche scale).

Key Words: age, egg quality, ISA Brown, layers, quails

## Introduction

The number of eggs is an important part of their production, as well as their quality. The quality of eggs is conditional upon a number of factors, such as poultry species, genotype, nutrition, environment, oviposition time, and the age of hens. Several investigations have been carried out on the changes that occur in the egg characteristics of laying hens throughout the course of the laying period. However, little detailed new information is available on changes in the characteristics of the quail egg.

The age of hens is another of the factors influencing egg weight. Johnston & Gous (2007) and Zita et al. (2009) showed that the egg weight increased with hen's age. The egg weight was also affected by the age of the quails. Nazligul et al. (2001) and Orhan et al. (2001) found that egg weight increased with the age of the quail. The shape index of the eggs may be affected by the age of poultry. Van den Brand et al. (2004) describe a decrease in the egg shape index with the age of laying hens. Orhan et al. (2001) showed the same trends in Japanese quails.

The increasing age of hens also led to increased yolk weight (Van den Brand et al., 2004; Zita et al., 2009) and yolk proportion (Rizzi & Chiericato, 2005; Zita et al., 2009). Zita et al. (2009) found that the yolk index decreased with the age of the hens. According to Nazligul et al. (2001), the yolk weight in Japanese quails is affected by the age, when yolk weight increases. Fletcher et al. (1983 ) found that quail eggs had higher proportions of yolk than those of hens.

The albumen weight increases with the hen age (Zita et al., 2009), while the albumen proportion decreases (Rizzi & Chiericato, 2005; Zita et al., 2009). As the quail ages, albumen weight increases (Nazligul et al., 2001). Fletcher et al.(1983) found that quail eggs have lower proportions of albumen than those of hens.

The Haugh unit score is the accepted unit for measuring the albumen quality of eggs. Abrahamsson & Tauson (1998) and Zita et al. (2009) found that the Haugh unit score decreased with the age of the hens. With increasing age of the quails, the Haugh unit score decreases as well (Nazligul et al., 2001; Orhan et al., 2001). On the other hand, Altan et al. (1998) observed that the Haugh units score did not change with quail age.

The age of the hens influences the eggshell quality (Silversides & Scott, 2001; Zita et al., 2009). As the hen ages, the eggshell proportion (Silversides & Scott, 2001; Zita et al., 2009) and eggshell thickness decreases (Abrahamsson & Tauson, 1998). Eggshell deformation increases with the increasing age of the hen (Wahlstrom et al., 1999). Eggshell quality characteristics are affected by the age of quails.

*Received April 28, 2011 and accepted February 2, 2012.*
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Nazligul et al. (2001) showed that the eggshell weight increased and eggshell thickness decreased with quail age (Nazligul et al., 2001; Orhan et al., 2001). Compared with the egg of hens, those from quails have poorer shell quality, as judged by shell thickness and shape (Fletcher et al., 1983).

The objective of this study was to evaluate the effect of the week of the laying period on egg quality measurements in laying-type hens and Japanese quails.

## Material and Methods

The monitoring was carried out on 144 brown-egg ISA Brown laying hens and 100 female Japanese quails (*Coturnix coturnix japonica*). Laying hens were housed in three-floor Big Dutchman Eurovent conventional cages (3 hens per cage – 550 $cm^2$ per hen). Quails were also placed in wire cages (3 females per cage – 400 $cm^2$ per quail). Temperature of 14 to 23 °C was maintained. The lighting regime consisted of 16 h of light and 8 h of darkness. Laying hens at the age between the 20th and 40th weeks were fed a commercial feed mixture with 11.4 MJ metabolizable energy (ME) and 16.7% crude protein. In the following period (between the 41st and 60th weeks of age) the hens were fed a mixture with 11.48 MJ ME and 15.4% crude protein. Japanese quails were fed a mixture with 11.2 MJ ME and 19.7% crude protein throughout the experimental period. Feed and water were provided *ad libitum*.

A total of 1,678 eggs from laying hens and 2,060 eggs from Japanese quails were used in the experiment, and all measurements were performed on each egg. The eggs were collected during 2 consecutive days during 4-week periods when the laying hens were from 20 to 60 weeks of age and the quails were from 9 to 49 weeks of age and weighed by using an electronic scale with 0.01 g sensitivity. Deformation of the eggshell and its strength were evaluated using the QC-SPA device (TSS England). Eggshell thickness was measured by the QCT device (TSS England). The albumen height and Haugh units were determined by the QCH and QCM+ device (TSS England). The height of thick yolk was recorded with a spherometer. The color of the yolk was recorded according to the La Roche scale (scores 1-15). The albumen and yolk were weighed, but eggshell was weighed after drying. The weight of each albumen, yolk and eggshell were recorded at the accuracy of 0.01 g. The proportions of yolk, albumen, and eggshell were calculated in relation to egg weight and expressed as percentages. Egg shape index, albumen index, yolk index and Haugh units score were computed as well.

All data of egg quality were analyzed using the UNIVARIATE, MEANS, and GLM procedures of software SAS (Statistical Analysis System, version 9.2). Normality tests were used to determine whether a data set was well-modeled by a normal distribution or not. An ANOVA with the general linear models procedure included the main effect of age and poultry species, and two-way interactions between these factors.

## Results and Discussion

It must be pointed out that some parameters, such as egg weight, eggshell strength and thickness, which are typical of the given species, cannot be statistically compared.

The average egg weight (Table 1) was significantly influenced by age of birds. The egg weight of hens increased advancing age up to the 16th week of laying, when it reached the highest weight, 63.44 g, followed by a minor drop in egg weight in the 20th week of laying, with a steadier decrease from the 24th week of laying period onwards. After that time, the egg weight fluctuated until the end of the egg production. The overall egg weight of the hens during the entire monitored period was 61.13 g. The results thus correspond only partly to the findings reported by numerous authors (Rizzi & Chiericato, 2005; Johnston & Gous, 2007; Zita et al., 2009), all of whom reported an increase in the egg weight for the duration of the laying period. A similar trend was observed in the development of egg weight for the Japanese quails which demonstrated a more rapid increase in the egg weight at the beginning of laying period, reaching the top (13.02 g) identically in the 16th week of laying, with subsequent gradual decreasing until the end of the laying period. The overall weight of the quail eggs for the entire monitored period was 12.52 g. Numerous authors (Altan et al., 1998; Nazligul et al., 2001; Orhan et al., 2001) have reported egg weight continuously increasing with increasing age and duration of laying. The results from this study correspond more to those reported by Ri et al. (2005), who reported increasing egg weight only between the 6th and 32nd weeks of age.

The egg shape index was significantly influenced not only by the particular poultry species but also by the week of laying in both poultry species. This indicator also demonstrated interaction of poultry species and age. In hens, the egg shape index, despite small variations, demonstrated a decreasing tendency with age, in line with conclusions published by Van den Brand et al. (2004). In Japanese quails, a somewhat opposite tendency was observed, in which the egg shape index values increased. Altan et al. (1998) stated that the egg shape index in Japanese quails was not influenced by age. However,

Orhan et al. (2001) confirmed a decreasing tendency of the egg shape index with increasing age, even in Japanese quails. Significant variations in the egg shape index were observed in both poultry species, when the overall average value for the Japanese quails was 77.85%, and 76.84% for the hens, indicating a rounder shape of the quail eggs.

Age was a significant factor in both poultry species clearly affecting the yolk index (Table 2). In hens, the highest value was recorded at the beginning of the laying period (50.82%), followed by a gradual decrease, despite some variations. Zita et al. (2009) also reported a decrease in the yolk index with age of hens. The overall average yolk index during the entire monitored period was 46.56%. This trend was not confirmed in the Japanese quails. The yolk index reached a relatively high value in the first week of the laying period (49.11%), followed by a marked drop in the 4th and 8th weeks, then maintaining approximately steady value until the 24th week of the laying period, when the highest value was reached (51.91%). From the 28th week onwards, the index continued to decrease significantly. The overall yolk index value in Japanese quails was 47.80%, indicating a significantly higher quality of yolk compared

Table 1 - Egg weight and egg shape index of ISA Brown laying hens and Japanese quails (*Coturnix coturnix japonica*) during different week periods

| Week of laying | Egg weight (g) | | Egg shape index (%) | |
|---|---|---|---|---|
| | ISA Brown | Japanese quail | ISA Brown | Japanese quail |
| 1 | 53.68±0.279 | 11.96±0.320 | 78.06±0.244 | 77.97±0.280 |
| 4 | 59.16±0.280 | 12.69±0.212 | 78.29±0.245 | 77.64±0.186 |
| 8 | 61.52±0.277 | 12.29±0.541 | 77.53±0.242 | 78.77±0.473 |
| 12 | 62.89±0.279 | 13.00±0.302 | 77.20±0.244 | 77.54±0.264 |
| 16 | 63.44±0.284 | 13.02±0.305 | 76.50±0.248 | 77.38±0.266 |
| 20 | 63.31±0.288 | 12.78±0.325 | 76.32±0.251 | 77.37±0.284 |
| 24 | 62.10±0.297 | 12.46±0.273 | 76.01±0.260 | 77.84±0.239 |
| 28 | 62.21±0.355 | 12.39±0.242 | 75.87±0.311 | 78.24±0.212 |
| 32 | 61.79±0.377 | 12.40±0.256 | 75.60±0.330 | 78.02±0.223 |
| 36 | 62.47±0.345 | 12.36±0.262 | 75.96±0.302 | 77.82±0.229 |
| 40 | 61.86±0.507 | 12.23±0.271 | 75.85±0.443 | 78.23±0.236 |
| Average | 61.13 | 12.52 | 76.84 | 77.85 |
| | | | Egg weight | Egg shape index |
| Significance | Poultry | | 0.001 | 0.001 |
| | Week of laying | | 0.001 | 0.001 |
| | Poultry* week of laying | | 0.001 | 0.001 |
| CV (%) | | | 11.15 | 4.32 |
| SEM | | | 0.402 | 0.056 |

CV - coefficient of variation; SEM - standard error of the mean.

Table 2 - Yolk quality traits of ISA Brown laying hens and Japanese quails (*Coturnix coturnix japonica*) during different week periods

| Week of laying | Yolk index (%) | | Proportion of yolk (%) | | Color of yolk | |
|---|---|---|---|---|---|---|
| | ISA Brown | Japanese quail | ISA Brown | Japanese quail | ISA Brown | Japanese quail |
| 1 | 50.82±0.294 | 49.11±0.337 | 22.34±0.224 | 28.96±0.257 | 6.17±0.064 | 4.87±0.073 |
| 4 | 44.21±0.294 | 47.66±0.223 | 24.34±0.224 | 29.84±0.171 | 5.76±0.064 | 4.70±0.048 |
| 8 | 46.70±0.291 | 46.81±0.569 | 25.94±0.222 | 30.31±0.435 | 5.82±0.063 | 5.04±0.123 |
| 12 | 46.30±0.294 | 46.82±0.317 | 25.97±0.224 | 30.76±0.242 | 5.90±0.064 | 4.93±0.069 |
| 16 | 47.79±0.298 | 46.83±0.320 | 26.97±0.228 | 30.31±0.245 | 5.66±0.065 | 4.81±0.069 |
| 20 | 46.77±0.303 | 48.05±0.341 | 26.89±0.231 | 30.63±0.261 | 5.66±0.066 | 4.95±0.074 |
| 24 | 46.39±0.312 | 51.91±0.288 | 26.80±0.239 | 30.74±0.220 | 5.75±0.068 | 4.78±0.062 |
| 28 | 45.15±0.374 | 50.81±0.255 | 27.28±0.285 | 30.73±0.194 | 6.41±0.081 | 4.85±0.055 |
| 32 | 46.42±0.400 | 47.34±0.269 | 27.24±0.303 | 30.96±0.205 | 6.55±0.086 | 4.92±0.058 |
| 36 | 43.95±0.363 | 45.25±0.275 | 27.90±0.277 | 30.66±0.210 | 5.97±0.079 | 5.00±0.060 |
| 40 | 45.45±0.533 | 44.15±0.285 | 25.52±0.407 | 30.62±0.224 | 5.37±0.112 | 4.98±0.062 |
| Average | 46.56 | 47.80 | 25.96 | 30.43 | 5.90 | 4.87 |
| | | | Yolk index | Proportion of yolk | | Color of yolk |
| Significance | Poultry | | 0.141 | 0.001 | | 0.001 |
| | Week of laying | | 0.001 | 0.001 | | 0.001 |
| | Poultry* week of laying | | 0.001 | 0.001 | | 0.562 |
| CV (%) | | | 8.52 | 10.82 | | 16.37 |
| SEM | | | 0.075 | 0.065 | | 0.017 |

CV - coefficient of variation; SEM - standard error of the mean.

with hens. The conclusions of some authors tend to differ markedly in the case of Japanese quails. Orhan et al. (2001) reported a decreasing yolk index with increasing age. This indicator was also found to interact with the poultry species and duration of the laying period.

The yolk proportion (Table 2) was significantly affected by the particular poultry species and duration of the laying period, with clear interactions observed. The yolk proportion increased in the hens for the duration of the laying period, with the only marked decrease observed in the 40th week. An increasing yolk proportion to egg weight with time of laying was also reported by Silversides & Scott (2001), Rizzi & Chiericato (2005), and Zita et al. (2009). The average yolk proportion for the duration of the laying period was 25.96 % in the hens. In the Japanese quails, the yolk proportion increased intensively during the first four weeks of the laying period. From week 8, the proportion remained steady and high until the end of the laying period. The average yolk proportion for the entire period of observation was 30.43%. A significantly higher yolk proportion to egg weight, compared with hen eggs, was also reported by Fletcher et al. (1983).

The yolk color (Table 2) was influenced by both the poultry species and duration of the laying period. No interaction was found, however. The yolk color of the hen eggs varied from 5.37 at the end of the laying period to 6.55 in the 32nd week, while any marked trend would be hard to define. The average yolk color was 5.90 of the Roche Yolk Color Fan. The observations were similar in the Japanese quails, with values ranging from 4.70 in the fourth week to 5.04 in the eighth week of the laying period. The average quail yolk color observed was 4.87. The results demonstrate that the most intense yolk color was found in the ISA Brown layers, compared with the Japanese quails.

The results show that the albumen index was significantly influenced by the poultry species and the week of the laying period, with mutual interactions detected (Table 3). Despite significant fluctuations during the laying period, the albumen index showed an overall decreasing tendency with increasing duration of the laying period. Similar results were reported by Zita et al. (2009). The albumen index in the Japanese quails also decreased with the progression of the laying period. Orhan et al. (2001) reported, however, that the albumen index in Japanese quails increased with age. The average albumen index in Japanese quails (10.39%) was significantly higher compared with that of hens (8.51%).

The albumen proportion to egg weight was influenced significantly by the poultry species and the age, as well as interactions between these factors. The albumen proportion gradually decreased in both poultry species, showing an opposite trend to that of the yolk, as demonstrated by the average values, while the albumen proportion was higher in the hens (61.80%) than in Japanese quails (56.93%). A decreasing tendency of the albumen proportion was also reported for hens by Van den Brand et al. (2004), Rizzi & Chiericato (2005), and for Japanese quails by Fletcher et al. (1983), who also reported a lower albumen proportion in Japanese quails compared with hens.

The albumen quality indication uses the Haugh unit score (Table 3). This indicator is also strongly influenced

Table 3 - Characteristics of albumen quality of ISA Brown laying hens and Japanese quails (*Coturnix coturnix japonica*) during different week periods

| Week of laying | Albumen index (%) | | Proportion of albumen (%) | | Haugh units score | |
|---|---|---|---|---|---|---|
| | ISA Brown | Japanese quail | ISA Brown | Japanese quail | ISA Brown | Japanese quail |
| 1 | 11.53±0.186 | 12.47±0.213 | 65.00±0.306 | 58.87±0.351 | 92.22±0.604 | 90.13±0.692 |
| 4 | 9.77±0.186 | 12.33±0.141 | 63.44±0.307 | 57.47±0.233 | 86.59±0.606 | 90.88±0.459 |
| 8 | 7.99±0.184 | 12.38±0.360 | 61.71±0.304 | 57.78±0.594 | 76.29±0.599 | 90.50±1.171 |
| 12 | 8.80±0.186 | 10.47±0.201 | 62.24±0.306 | 56.65±0.331 | 83.10±0.604 | 85.98±0.653 |
| 16 | 7.72±0.189 | 10.54±0.203 | 61.28±0.311 | 57.79±0.334 | 78.39±0.614 | 87.13±0.659 |
| 20 | 7.75±0.191 | 9.86±0.216 | 60.79±0.316 | 56.45±0.356 | 80.05±0.622 | 85.10±0.702 |
| 24 | 7.68±0.198 | 10.29±0.182 | 60.94±0.326 | 56.89±0.300 | 79.15±0.643 | 85.47±0.591 |
| 28 | 7.33±0.236 | 9.53±0.161 | 60.34±0.390 | 57.08±0.265 | 82.12±0.769 | 83.89±0.524 |
| 32 | 7.65±0.251 | 8.92±0.170 | 60.09±0.414 | 56.19±0.280 | 83.50±0.816 | 82.98±0.553 |
| 36 | 7.40±0.230 | 8.88±0.174 | 59.79±0.378 | 55.82±0.287 | 75.94±0.747 | 82.90±0.566 |
| 40 | 8.91±0.337 | 9.84±0.180 | 62.39±0.556 | 56.17±0.297 | 81.99±1.097 | 85.15±0.586 |
| Average | 8.51 | 10.39 | 61.80 | 56.93 | 81.91 | 86.15 |
| | | | Albumen index | Proportion of albumen | Haugh units score | |
| Significance | Poultry | | 0.001 | 0.001 | 0.001 | |
| | Week of laying | | 0.001 | 0.001 | 0.001 | |
| | Poultry* week of laying | | 0.001 | 0.001 | 0.001 | |
| CV (%) | | | 26.68 | 7.11 | 9.83 | |
| SEM | | | 0.049 | 0.081 | 0.153 | |

CV - coefficient of variation; SEM - standard error of the mean.

by the poultry species and age, with identified interactions. Despite numerous deviations, the Haugh units score demonstrated a declining trend in both poultry species, corresponding to the results reported by several authors: Abrahamsson & Tauson (1998), and Zita et al. (2009) in hens, and by Nazligul et al. (2001) and Orhan et al. (2001), in Japanese quails. Altan et al. (1998), however, observed no changes in the Haugh units score in the course of the laying period. A comparison between the poultry species (hens 81.91, quails 86.15) clearly shows a higher albumen quality in the Japanese quails.

Eggshell quality is an important indicator of the egg value (Table 4). The eggshell proportion did not manifest poultry species dependency. On the other hand, the influence of age was clearly demonstrable in both poultry species, and interactions were found between the poultry species and the week of the laying period. Despite this indicator showing significant fluctuation in hens, a decreasing tendency of the eggshell proportion could be detected towards the end of the laying period. The results observed correspond in part to the data of some authors (Abrahamsson & Tauson 1998; Wahlstrom et al. 1999; Silversides & Scott 2001; Zita et al. 2009), who report decreasing eggshell proportion with hen age. In Japanese quails, on the other hand, the eggshell proportion tended to increase towards the end of the laying period. The average values of the eggshell proportion for the laying period were 12.24% in hens and 12.65% in Japanese quails.

The poultry species and the week of the laying period affected the incidence of eggshell deformations. Eggshell deformation in hens indicated that the highest shell quality persisted in the middle of the laying period (showing the lowest deformation values) with lower eggshell quality at the beginning and the end of the laying period. These values, too, correspond only partially to observations reported by some other authors (Abrahamsson & Tauson 1998; Wahlstrom et al. 1999), who found increasing eggshell deformation frequency with the age of the hens. In Japanese quails, the highest deformation incidence values were observed towards the end of the laying period, probably due to the concurrent increase of the eggshell proportion. A comparison between the poultry species shows a better quality of the eggshell of quails, with a lower incidence of deformation. Eggshell deformation indicated no interaction between poultry species and age.

Eggshell strength (Table 4) was related to the different eggshell thickness in both species, and was strongly influenced by the particular poultry species as well as the age of the hens. However, no mutual interactions were detected. Despite frequent fluctuations, the eggshell strength decreased in the course of production.

The relationship between poultry species and eggshell thickness (Table 4), which is also influenced by age in both hens and quails was detected. No interactions were observed. Poorer eggshell quality, expressed by the eggshell thickness, in the Japanese quails was reported

Table 4 - Parameters of eggshell quality of ISA Brown laying hens and Japanese quail (*Coturnix coturnix japonica*) during different week periods

| Week of laying | Proportion of eggshell (%) | | Eggshell deformation (mm) | | Eggshell strength (g.cm$^{-2}$) | | Eggshell thickness (mm) | |
|---|---|---|---|---|---|---|---|---|
| | ISA Brown | Japanese quail | ISA Brown | Japanese quail | ISA Brown | Japanese quail | ISA Brown | Japanese quail |
| 1 | 12.66±0.187 | 12.17±0.215 | 0.39±0.013 | 0.33±0.015 | 4,874±51.457 | 1,442±59.001 | 0.360±0.002 | 0.189±0.003 |
| 4 | 12.23±0.188 | 12.70±0.142 | 0.40±0.013 | 0.33±0.010 | 5,088±51.595 | 1,569±39.137 | 0.371±0.003 | 0.186±0.001 |
| 8 | 12.36±0.186 | 11.91±0.363 | 0.39±0.013 | 0.34±0.025 | 4,855±51.052 | 1,563±99.779 | 0.355±0.003 | 0.194±0.005 |
| 12 | 11.79±0.187 | 12.59±0.202 | 0.38±0.013 | 0.36±0.014 | 4,877±51.457 | 1,537±55.605 | 0.363±0.003 | 0.184±0.003 |
| 16 | 11.75±0.190 | 11.90±0.204 | 0.38±0.013 | 0.35±0.014 | 4,701±52.299 | 1,592±56.130 | 0.361±0.003 | 0.195±0.003 |
| 20 | 12.32±0.193 | 12.93±0.218 | 0.37±0.013 | 0.31±0.015 | 4,578±53.032 | 1,632±59.844 | 0.367±0.003 | 0.210±0.003 |
| 24 | 12.26±0.199 | 12.38±0.183 | 0.41±0.014 | 0.36±0.013 | 4,642±54.761 | 1,374±50.396 | 0.375±0.003 | 0.191±0.002 |
| 28 | 12.38±0.238 | 12.19±0.162 | 0.36±0.026 | 0.34±0.011 | 4,705±65.508 | 1,461±44.622 | 0.364±0.003 | 0.192±0.002 |
| 32 | 12.67±0.253 | 12.84±0.171 | 0.34±0.027 | 0.34±0.012 | 4,670±69.520 | 1,426±47.141 | 0.369±0.003 | 0.191±0.002 |
| 36 | 12.32±0.231 | 13.53±0.181 | 0.37±0.026 | 0.36±0.012 | 4,566±63.617 | 1,309±48.230 | 0.364±0.003 | 0.183±0.002 |
| 40 | 12.10±0.340 | 13.21±0.187 | 0.40±0.023 | 0.39±0.012 | 4,495±93.452 | 1,353±49.889 | 0.337±0.005 | 0.181±0.002 |
| Average | 12.24 | 12.65 | 0.38 | 0.35 | 4,763 | 1,468 | 0.364 | 0.190 |

| | | Proportion of eggshell | Eggshell deformation | Eggshell strength | Eggshell thickness |
|---|---|---|---|---|---|
| Significance | Poultry | 0.933 | 0.001 | 0.001 | 0.001 |
| | Week of laying | 0.001 | 0.012 | 0.001 | 0.001 |
| | Poultry* week of laying | 0.001 | 0.628 | 0.120 | 0.253 |
| CV (%) | | 20.59 | 48.57 | 23.94 | 12.74 |
| SEM | | 0.042 | 0.003 | 29.260 | 0.002 |

CV - coefficient of variation; SEM - standard error of the mean.

earlier by Fletcher et al. (1983). Eggshell thickness, despite frequent fluctuations, demonstrated a declining tendency, especially towards the end of the laying period. Similar conclusions were reported in the studies of Abrahamsson & Tauson (1998), Altan et al. (1998), Nazligul et al. (2001) and Orhan et al. (2001).

## Conclusions

The indicators of the technological value of eggs demonstrate that egg weight and the egg shape index are influenced not only by the particular poultry species, but also by the age of the poultry. A gradually decreasing yolk index can be reported for both poultry species, with a higher average achieved by the Japanese quails. Also, the yolk proportion increases in both poultry species, with a markedly higher proportion in the Japanese quails. Higher values of the albumen index are observed in the Japanese quails, while it decreases with the progression of the laying period in both poultry species. Hens demonstrate a higher albumen proportion than Japanese quails, however, of poorer quality than the latter, as expressed by the Haugh unit score. By its strength and thickness, the eggshell quality demonstrates a strong dependency on the particular poultry species, and both indicators show a declining tendency on the course of the laying period.

## Acknowledgments

This study was supported by the Ministry of Education, Youth and Sports of the Czech Republic, Project No. MSM 6046070901.

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