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EFFECT OF DIFFERENT STORAGE TIMES ON JAPANESE QUAIL EGG QUALITY CHARACTERISTICS

Sylvie Ondrušíková, Šárka Nedomová, Roman Pytel, Olga Cwiková, Vojtěch Kumbář

ABSTRACT

The aim of this research was to monitor selected quality parameters of Japanese quails (*Coturnix coturnix japonica*) – the loss of egg weight, changing yolk and white index, Haugh units, egg yolks color. Quail eggs were stored for 0, 1, 2, 4, 6 and 8 weeks at 4 °C. The weight of the quail eggs ranged from 11.67 to 12.27 g. The ratio of the shell range 7.60 to 8.16 % (resp. 0.89 – 0.96 g), ratio of egg white from 59.33 to 62.10 % (resp. 6.31 – 6.66 g) and a ratio yolk of 30.13 – 32.88 % (resp. 3.68 – 3.91 g). The lost of egg weight ranged from 0.47 to 2.93 % during the quail eggs storage, corresponding to a weight loss of 0.26 – 0.58 g of the total weight of the eggs. The average values of the yolk index ranged from 42.67 – 48.53 % and the average values of the quail egg white index ranged from 6.77 to 11.35 %. The average Haugh units were set between 56.93 and 73.72. The color of quail egg yolk was determined using the La Roche scale with the most frequent value 3. During the quail eggs storage, a statistically significant difference was found with most of the quality traits observed.

Keywords: quail eggs; egg quality parameters; storage time; storage temperature

INTRODUCTION

Egg as a nutritionally balanced and easily digestible nutritional ingredient is one of the frequent foods appearing on the menu. Hen eggs are the most commonly consumed, although Japanese quail eggs (*Coturnix coturnix japonica*) are also readily available today, which are considered to be nutritionally important to consumers, mainly due to their rich vitamin and mineral content. Despite the small size (approximately 10 – 12 g), quail eggs are also rich in proteins, amino acids, macro and microelements (calcium, selenium and zinc) and have low triglyceride and saturation fatty acids. Some countries have a long tradition of consuming quail eggs such as Japan, where quail eggs are considered to be almost natural medicine, especially to reduce cholesterol, blood pressure, increased immunity and allergy treatment (Baumgartner and Hetényi, 2001; Angelovičová et al., 2013).

In the Czech Republic, the production of quail eggs is not as wide as it is in other countries. The most significant producer quail eggs are China, Japan, Brazil and France. The production and consumption of eggs bear certain requirements that are necessary to maintain egg quality. These include good hygienic practice, in particular length and temperature of storage. The storage period for fresh eggs is set at 28 days and must be sold to the consumer within 21 days at the latest, so that they have enough time to process them (Regulation (EC) No.

853/2004). Temperature requirements vary slightly from country to country and are determined by temperatures ranging from 5 °C to 18 °C for the Czech Republic (Decree No. 69/2016 Coll. of Czech Republic).

The quality of the egg is usually given in relation to the requirements of consumers and determines the general characteristics which are easily identifiable without breaking the egg, especially the freshness, weight, size, shape and appearance of the eggshell. More precisely, the quality characteristics are determined by the individual egg fluids and the shells can be distinguished. The quality of quail eggs is mainly dependent on the breed, the age laying hens, the composition of the feed, and also the storage time and temperature. For the consumer, one of the most important features is the weight of the egg, as well as the visual aspect of the egg purity and the integrity of the eggshell.

Japanese quails are due to their easy care, early sexual maturity and above all a high degree of egg production used in research. And in some countries (Poland, Hungary) are increasingly used in the food industry.

Egg quality parameters include general characteristics – in particular weight, size, egg shape and shell appearance. Another very important feature is the shell integrity, which is important not only from the economic point of view, but also with regard to the safety of human health (Yanakopoulous, 1986).

Quail eggs quality is divided into external and internal quality parameters (Arpášová et al., 2012). The outer

quality features include the weight, the shape of the egg, the quality of the egg shell, the structure of the shell, the strength, the porosity and the color. **Baumgartner and Hetényi (2001)** presented in his study weight whole egg 10.16 g, shaped index 85.70 % and shell strength 24.40 N.

The weight of quail eggs is a significant indicator of total egg production and is about 5 times lower than that of hen eggs. The average weight of quail eggs ranges from 10 to 12 g, which is about 8 % of the total weight of the hen (**Panda and Singh, 1990**). The size and hence the weight of the quail eggs is influenced by several factors such as the age of the laying hens, the breed, genetics, climatic conditions, the season, the composition of the feed or the length of the laying (**Nowaczewski et al., 2010b**).

However, quail eggs are not a constant indicator and are dependent on a number of working indicators such as genotype, length and storage temperature and age of laying (**Alkan et al., 2008**).

The internal characters are divided into individual egg components, ie the egg albumen is determined by the albumen index, Haugh unit and its weight is calculated. **Baumgartner and Hetényi (2001)** reported values of index albumen 11.30 %, Haugh units 114.50, and weight of egg albumen 5.12 g for quail eggs. For the yolk part was monitored the yolk index, weight and their color, subjectively determined by the La Roche scale, are followed. These values are reported in **Baumgartner and Hetényi (2001)**, where the yolk index was 50.40 % and the yolk weight 3.22 g. Neither quail eggshell are neglected in terms of quality and their weight is followed after thorough cleaning and drying, but also the thickness of the shell at the blunt and sharp end of the egg.

The quality of quail eggs, however, also depends on a number of internal as well as external influences, whether in pre-laying or laying on eggs. This quality can therefore be affected by the age of laying hens, feed composition, controlled farming conditions, storage temperature and time, relative humidity and other influences (**Baumgartner and Hetényi, 2001**).

Scientific hypothesis

The main hypothesis of this work is to determine qualitative parameters quail eggs during 8 week storage with constant temperature 4 °C.

MATERIAL AND METHODOLOGY

To determine the selected qualities of quail eggs and their changes during storage was used of Japanese quail egg (*Coturnix coturnix japonica*) the breed Pharaon in 20th week of age from cages in South Moravia, which supplies quail eggs to the market network. Quails were fed a complex feed mixture throughout the laying season. Complex feed mixture was composit from wheat (30 %), maize (28 %), soybean extruded toast (18 %), fish meal (6 %), wheat bran (4%), alfalfa meal (3 %), calcium carbonate (4 %), L-lysine, DL-methionine, vitamin A, D3, E, copper sulfate pentahydrate (CuSO₄.5H₂O), butylhydroxyanisole, butylhydroxytoluene, etoxyquin.

Quail eggs were removed and imported on the day of laying. All fresh eggs were first weighed, labeled and stored at 4 °C at 75 % relative humidity. The length

of quail eggs storage was 0, 1, 2, 4, 6 and 8 weeks, and a total of 120 quail eggs were used to monitor the quality characteristics. In each storage week, the following quality parameters were analyzed 20 eggs.

At sampling, eggs were weighed and broken on to a flat surface where the height of the albumen was measured by using albumen height gauge. The thick of albumen were measured using micrometer. The yolk was separated from the albumen and was weighed. The shells were dried at 130 °C temperature during 60 minutes and weighed. The shell thickness were measured from the three different parts of shell in each (sharp, blunt and equator end of egg) using a micrometer and was averaged and recorded as shell thickness. The weight of the albumen was calculated as the difference between the weight of the egg and the weight of the yolk and shell. The color of yolk was determined by the La Roche color scale.

Egg quality parameters were calculated as:

Haugh unit = $100 \times \log (\text{Albumen height} + 7.57 - 1.7 \times \text{Egg weight}^{0.37})$ (**Haugh, 1937**).

Albumen index = Albumen height (mm) / [Albumen length (mm) + Albumen width (mm)] × 100.

Yolk index = Yolk height (mm) / Yolk diameter (mm) × 100.

Egg weight loss = [(Egg weight - Egg broken weight) / Egg weight] × 100.

Shape index = maximum width (mm) / maximum length (mm) × 100.

Statistic analysis

Statistical analysis of the differences was based on Statistica12 (StatSoft, Czech Republic), namely single-factor ANOVA – Duncan's test. Microsoft Excel version 2010 (Microsoft) was used to evaluate the results. The statistically inconclusive difference was considered to be a result whose probability value reached $p > 0.05$.

RESULTS AND DISCUSSION

The egg weight and egg weight loss of quail eggs

The average weights of the fresh quail eggs (12.00 g) are considerably higher, then values **Panda and Singh (1990)** and **Nowaczewski et al. (2010b)**. On the contrary, **Alkan et al. (2011)** and **Genchev (2012)** indicate the quail eggs weighing values lower, due to the age and breed of Japanese quail. **Baylan et al. (2011)** is the average weight of quail eggs at the same level as our measurements. Our results correlate with the results of **Nowaczewski et al. (2010b)** where the average weight of quail eggs during storage gradually decreased from 11.37 to 11.00 g. The weight loss values of quail eggs increased from 0.47 % (1st week of storage) to 2.93 % (8th week of storage) which is caused when the water contained in the eggs had evaporated. The weight loss in quail eggs during storage was almost linearly increased, which corresponds to the claim by **Roriz et al. (2016)**, which also reported the highest weight loss in the 6th week of storage with a loss of 2.40 % of the original weight. The statistical significant of weight and weight loss during storage is given in the Table 1.

The egg shell thickness, shell weight and shell ratio of quail eggs

The ratio of the shell from the total weight of quail eggs ranged from 7.60 to 8.16 %. The lowest individual egg shell ratio for quail eggs was 5.34 %, whereas the highest individual shell ratio was 9.58 %. Creation and shell thickness favorably affects feeds rich on minerals, especially calcium, while high chlorine content in feed, uneasiness of laying hens, and high ambient temperatures can have a negative impact on the thickness and strength of the shell. The average shell thickness for quail eggs ranges from 0.10 to 0.14 mm. The lowest individual shellfish shell thickness of the quail eggs was 0.05 mm, while the highest individual value was 0.22 mm.

The ratio of the shell from quail eggs coincides with that of **Akpınar et al. (2015)**, where the ratio of quail eggs was 8.14 – 8.40 %. Our results ranged from 7.60 % (8th week of storage) to 8.16 %, which was found in eggs at the 4th week of storage. In the **Olgun (2015)** study, the shell ratio values are closest to our closest values, with a difference of only 0.01 %, which correlates with the shell thickness, which in this case was 0.17 mm. The statistically significant of weight and weight loss during storage is given in the Table 1.

However, the shell ratio is lower than **Genchev (2012)**, **Wilkanowska and Kokoszyński (2012)**, which is attributed to the quail eggs of another breed. **Baumgartner and Hetényi (2001)** show the shell ratio values also higher than those we achieved in the measurement, up to 9.51 % and similarly determined shell share in **El-Tarabany et al. (2015)**, when the difference to our results was 2.47 %. Deviations between results may be due to different breeding factors, which is related to egg weight and feed composition, which correlates with egg shell thickness and therefore its ratio. However, the results show that the shelf life of egg shells in quail eggs has minimal demonstrable effect.

Albumen weight and albumen ratio of quail eggs

The average ratio of egg albumen in quail eggs ranged from 60.13 % (Table 2) in freshly eggs, followed by an increase in the albumen ratio by an average of 1.8 % after the first week of storage. The increase in the proportion of egg whites in quail eggs was recorded only after the end of the 2nd week of storage, and thereafter the amount of albumen began to decrease, which correlates with the increasing proportion of yolk

when osmotic pressure is due to the diffusion of water from the part of the albumen to the yolk. The average values of the albumen ratio of the quail eggs range from 59.33 to 62.10 %, corresponding to a weight of 6.31 – 7.31 g. The proportion of albumen from the total weight of quail eggs (60.50 %) corresponds to the weight categories of eggs according to **Nowaczewski et al. (2010b)** between egg sizes S and M. These values are slightly higher than reported by **El-Tarabany et al. (2015)** and **Zeweil et al. (2016)**. The **Baylan et al. (2011)** reached slightly higher scores versus 60.50 % with albumen ratio of 61.68 %. The decrease in the proportion of the albumen also dependent on the storage temperature, when **Inci et al. (2015)** for stored eggs at 28 °C shows a ratio of albumen after storage of 58.58 % after storage for ten days and 55.78 % under the same conditions after 20 days of storage.

Different values of the ratio of albumen in quail eggs may be different temperature and relative humidity of storage as well as breed or age of laying hens. **Nowaczewski et al. (2010b)** shows the weight of the albumen before storage of 7.05 g and after 8 days of storage 6.70 g, of which the effect of shelf life on the weight of egg albumen which is due to the migration of water contained in the white part into the yolk.

Albumen index and Haugh units of quail eggs

One of the most important qualities of quail eggs is the albumen egg index, which closely correlates with the height and width of the albumen, when it is easy to determine the albumen index and, therefore, its quality quail eggs during storage. However, the age of the laying hen and especially the storage length and temperature affect by the value of the albumen index. The average values of the dense albumen index ranged from 6.77 % (8th week of storage) to 11.35 % achieved at week 2nd storage (Table 2). The lowest individual index of albumen index for quail eggs was recorded at the 8th week of storage, namely 0.18 %, while the highest individual index values of white were reached in the 4th week of storage with a value of 20.07 %. The values of the albumen index of our quail eggs almost coincide with the results of **Baumgartner and Hetényi (2001)** for Japanese quail eggs stored at 4 °C. In contrast, **Baylan et al. (2011)** also monitored the albumen index of samples stored at 20 °C and proved the negative effect the temperature, where this value decreased compared to samples stored at refrigerated temperature by 4.75 %. **Bagh et al. (2016)** also

Table 1 Effect of storage time on exterior characteristics of quail eggs.

Length of storage [week]	0	1	2	4	6	8
Egg weight, [g]	12.27	12.17	12.18	11.80	11.94	11.67
Egg weight loss, [%]	-	0.47 ^b	1.11 ^a	1.20 ^a	1.93 ^c	2.93 ^d
Shape index, [%]	74.85	76.43	77.33	78.85	76.86	76.61
Egg shell thickness, [mm]	0.12 ^{b,c}	0.14 ^c	0.11 ^{a,b}	0.14 ^c	0.10 ^{a,b}	0.10 ^a
Shell weight, [g]	0.99 ^b	0.94 ^{a,b}	0.94 ^{a,b}	0.96 ^{a,b}	0.95 ^{a,b}	0.89 ^a
Shell ratio, [%]	8.08 ^{a,b}	7.71 ^{a,b}	7.76 ^{a,b}	8.16 ^b	7.94 ^{a,b}	7.60 ^a

Note: ^{a, b, c, d} – different superscripts in a line indicate a statistically significant difference at $p < 0.05$.

Table 2 Effect of storage time on interior characteristics of quail eggs.

Length of storage [week]	0	1	2	4	6	8
Albumen weight, [g]	6.67 ^a	7.01 ^b	6.66 ^a	6.85 ^{a,b}	7.31 ^b	6.31 ^a
Albumen ratio, [%]	60.13 ^{a,b}	61.21 ^{b,c}	62.10 ^c	60.69 ^{a,b,c}	59.33 ^a	59.52 ^{a,b}
Yolk weight, [g]	3.91	3.78	3.68	3.68	3.91	3.84
Yolk ratio, [%]	31.79 ^{a,b}	31.07 ^{a,b}	30.13 ^b	31.15 ^{a,b}	32.73 ^a	32.88 ^a
Yolk index, [%]	47.04 ^{c,d}	46.34 ^{b,c,d}	48.53 ^d	44.27 ^{a,b,c}	42.67 ^a	43.60 ^{a,b}
Albumen index, [%]	9.37 ^{a,b}	11.35 ^b	10.19 ^{a,b}	10.47 ^{a,b}	8.56 ^{a,c}	6.77 ^c
Haugh unit	66.25 ^{a,b}	73.72 ^b	67.57 ^{a,b}	66.34 ^{a,b}	61.52 ^{a,c}	56.93 ^c
Yolk color	3	3	3	3	3	4

Note: ^{a, b, c, d} – different superscripts in a line indicate a statistically significant difference at $p < 0.05$.

reached slightly higher values which are caused to the different breeds of lay hens between experiments. Somewhat higher values of the quail egg albumen index were achieved by Nowaczewski et al. (2010a), by only 1.33 %. Haugh units are based on the weight of fresh quail eggs and the height of the dense albumen. The average Haugh unit values quail eggs was the range from 56.93 (8th week of storage) to 73.72 (1st week of storage). In freshly laying quail eggs, the average Haugh units reached 66.25. The lowest individual value of Haugh units during storage was set at the 8th week of storage, namely 23.81. The highest individual value of the Haugh units showed samples at the 4th week of storage, when this quality indicator reached the 94.53. Initial values of Haugh units are significantly lower than stated in their Baumgartner and Hetényi (2001) study, which states the average value of Haugh units of 114.40. The closest to the results of the study is Kumari et al. (2008), which shows the average value of the Haugh units of 59.50. Nowaczewski et al. (2010b) have shown in their study that Haugh units are being reduced during storage, with which our results are identical, which is related to changes in dense egg albumen during storage when it is thinned.

The yolk weight, yolk ratio, and yolk index of quail eggs

The average yolk index values for quail eggs during storage were 42.67 % (6th week) and 48.53 % (2nd week of storage), with average yolk weight 3.68 - 3.91 g (Table 2). For fresh eggs was yolk index 47.04 %. However, from the 4th week of storage, the yolk index was reduced by up to 3.44 % (8th week of storage) compared to fresh eggs. The yolk index for quail eggs almost coincides with those reported in El-Tarabany et al. (2015), Wilkanowska and Kokoszyński (2012) and Inci et al. (2015). Higher values of the yolk index at the beginning of the experiment were showed by Nowaczewski et al. (2010a), where the freshly laid eggs had an index value of 3.26 % higher than that of our samples at the same time. In all of these studies, the yolk index during storage decreases, which is due to the migration of water between the egg albumen and egg yolks.

Yolk color

The yolk color of Japanese quail eggs is one of the important characteristics of egg quality. However, this fact is very easily influenced, especially by feeding a feed, either in the form of natural, ie green feed, or in the form of carotenoid-enriched compound feeds. The most common yolk color in quail eggs is 3 (Table 2). During stocking, honey yolk quark color values were recorded using a La Roche scale ranging from 1 to 5. The highest shade of 4 was determined in egg yolks of quail eggs at the 8th week of storage. In the other weeks of storage, the highest color values of yolk quail eggs were identical, with a value of 3. The lowest shade of value 1 was, in addition to the 4th week of storage, set in all the remaining weeks. The most common color of egg yolk in Japanese quail eggs coincides with the results of Kara et al. (2016). Similar results were obtained in Pereira et al. (2016) with a color shade of 4. The significantly higher values compared to our results were obtained in the Cayan and Erenler (2015) studies, which determined the average frequency of egg yolk color 12. El-Tarabany study (2016) indicates the range of egg yolk color in Japanese quails between 7 and 9.

CONCLUSION

This contribution was focused on the change of qualitative parameters of quail eggs during storage.

The results of this study show the increase in egg weight loss during storage, the increase the yolk ratio during storage, the decrease the albumen ratio, the reduction of white and yolk index, the reduction of Haugh units during storage.

The loss of egg weight during storage occurs due to the evaporation of water from the egg, but also due to the loss of carbon dioxide, ammonia, nitrogen and hydrogen sulphide. During storage, the yolk index is also reduced, which is caused by the diffusion of water into the white part, which also leads to a decrease in the albumen index and leads thinned and the structure changes. The decrease in the albumen index is correlated with the decrease in Haugh units.

These changes during a storage lead to a deterioration in the quality of quail eggs and it is recommended low temperature storing to preserve quality parameters during 8 week storing.

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Contact address:

Ing. Sylvie Ondrušíková, Mendel University in Brno,
Faculty of AgriSciences, Department of Food Technology,
Zemědělská 1, 613 00 Brno, Czech Republic,
E-mail: sylvie.ondrusikova@mendelu.cz

doc. Ing. Šárka Nedomová, Ph.D., Mendel University in
Brno, Faculty of AgriSciences, Department of Food
Technology, Zemědělská 1, 613 00 Brno, Czech Republic,
E-mail: snedomov@mendelu.cz

Ing. Roman Pytel, Mendel University in Brno, Faculty of
AgriSciences, Department of Food Technology,

Zemědělská 1, 613 00 Brno, Czech Republic, E-mail:
roman.pytel@mendelu.cz

MVDr. Olga Cwiková, Ph.D., Mendel University in Brno,
Faculty of AgriSciences, Department of Food Technology,
Zemědělská 1, 61300 Brno, Czech Republic,
E-mail: cwikova@mendelu.cz

doc. Ing. Vojtěch Kumbář, Ph.D., Mendel University in
Brno, Faculty of AgriSciences, Department of Technology
and Automobile Transport, Zemědělská 1, 613 00 Brno,
Czech Republic, E-mail: vojtech.kumbar@mendelu.cz