OPEN ACCESS Potravinarstvo® Scientific Journal for Food Industry

*Potravinarstvo*, vol. 9, 2015, no. 1, p. 442-450
doi:10.5219/515
Received: 16 September 2015. Accepted: 28 October 2015.
Available online: 17 December 2015 at www.potravinarstvo.com

ISSN 1337-0960 (online)


# THE TABLE EGGS AND THEIR QUALITY IN SMALL-SCALE BREEDING

*Mária Angelovičová, Lucia Ševčíková, Marek Angelovič*

## ABSTRACT

The purpose this study was to investigate quality of the table eggs, their damage and soiling in various age of the laying hens (47-62 weeks) during the second phase of the laying cycle. The object of the research was table eggs, egg white, egg shell, damage and soiling of the egg shell. The eggs were of the final laying hybrid ISA Brown reared in the non-cage system with deep litter and free range at small-scale breeding. In the breeding system with free range at small-scale conditions were secured requirements for laying hens in accordance with welfare principles. The eggs were collected each day at 4:00 pm. Weights of egg and egg shell samples of were measured on scales type KERN 440-35N. A white weight was calculated. Damage and soiling of eggs were investigated under the desk lamp lighting up to 100 W bulb. Statistical evaluation of the results was carried out in the program system SAS. From the existing conclusions of the various scientific and professional published works, it is known that both quality and safety are interrelated. In many works are the risk factors referred together as the quality standards. We found an important fact in assessing the trend of values of the egg shell weight, depending on the age of laying hens. Based on this fact, it can be assumed that the values of egg shell weight were not directly related to egg weight and egg white weight. It follows that the egg shell weight must be assessed comprehensively, and account must be taken of other factors. For the characteristics of the deformed egg shape has been one pc, representing 3.33% of the samples taken for analysis of eggs at 53 weeks of age of the total sampled eggs. In the following 56 weeks of age hens laying eggs there was not a deformed shape. The next subsequent sampling 59 weeks of age laying hens were recorded two pcs of eggs with deformed shape, i.e. 6.67%. At the last sampling of eggs at age 62 weeks, the number of eggs with deformed shape increased to three pcs, representing 10.0% of the sampled eggs for analysis. The sediments on the shell eggs were observed as variable ridge shapes of the shell matter. At the first sampling of eggs at age 47 weeks were found 2 pcs of this defect, representing 6.67% of the sampled eggs. The ridges on the egg shell belong to deviations of the natural shell associated with its texture. These defects of egg shell frequently occur depending on the age of laying hens but can also be caused by other factors. In our experiment was studied mainly the age factor of laying hens. It was interested from aspect of clarifying the relation between ridges on the egg shell and weight of the egg, white, egg, respectively. The results of investigated ridges on the egg shell showed that there occurred in every age of laying hens. Their highest number was recorded at age 59 and 62 weeks (5 pcs, i.e. 16.67% of the 30 egg samples). After 59 weeks of age was found also reduce the weight of the white and shell and at age 62 weeks of age was reduced egg shell weight. Egg production with calcareous sediments on the shell is probably hereditary. Currently, the consumer prefers the consumption of eggs with brown shell. Egg shell color is determined primarily by genetics of laying hens. The results of our experiments have shown that the occurrence of the dots on egg shell had a shade darker brown colour or bright dots, especially on the ends of the egg. The occurrence of dotted eggs was recorded in each assessed age of laying hens (5 – 7 pcs, i.e. 16.67 to 23.33%), while in the last, evaluated 62 weeks of age even up to 9 pcs. These dots and their occurrence are related to the intensity of pigment deposition in the shell cuticle. The process of distribution of pigment in egg shell is the same as is formed by packing egg shell and therefore the cuticle. With the increasing age of laying hens reduces the intensity of pigment deposition in the egg shell and increases of egg surface area, of the egg shell area, to which the pigment is stored. This fact is confirmed by our results especially at week 62 of age, when occurrence of pigment dots was the highest on the shell and also these eggs had the highest average weight.

**Keywords**: table egg; egg shell; demange; soiling; age of laying hen

## INTRODUCTION

Raising awareness of food safety among consumers of the table eggs was observed a change in perception of egg quality through high quality and health-safe, clean egg shell. The shell is a natural food packaging material of egg contents. Quality and safe egg shell are generally assessed based on physical properties and microbiological integrity. The microorganisms can contaminate the eggs at different stages of their production, processing until preparation and consumption. A brief overview of requirements for table

eggs distributed worldwide is clearly illustrated. According to European regulations eggs, which are intended for the EU market are classified as the eggs of class A or B **(Commission Regulation (EC) No 2295/2003; Council Regulation (EC) No. 1028/2006)** and only graded eggs can be sold for the purpose of direct human consumption or sold at retail **(Council of the European Union, 2006)**. Similarly, the US Department of Agriculture (USDA) has approved three levels of these eggs in the basic of internal egg quality, appearance and condition of the shell **(USDA Food Safety and Inspection Service, 2013)**. AA grade eggs and A grade eggs are generally intended for sale to the consumer and B grade eggs are usually destined for further processing.

Conventional cages are banned for rearing of laying hens in the European Union since 2012, according to the EU directive 1999/74 **(Council Directive 1999/74/EC on 19 July 1999)**.

Since 2012, the laying hens can be kept in the enriched cage systems or non-cage systems which can be applied aviary, litter, respectively. The alternatives to conventional cages were till now more evaluated from a business perspective, in terms of productivity and welfare of laying hens **(Abrahamsson and Tauson, 1995; Tauson et al., 1999; Tauson, 2002; Wall and Tauson, 2002; Wall et al., 2002; Rodenburg et al., 2005, 2008)**.

Furthermore, attention was paid to influence of breeding system of the laying hens on the egg hygiene. A development towards the of farming in the enriched cages and non-cage-system may have consequences for the deterioration of egg hygiene and increase the percentage of the cracked and dirty eggs **(Wall and Tauson, 2002)**, bacterial contamination of egg shell, respectively **(De Reu et al., 2005; Mallet et al., 2006)**.

The high number of cracked eggs have a negative impact on the efficiency of production of table eggs and breeding economy of the laying hens on the farm. One of the most obvious reasons for egg shell cracking (including thick cracks, hairline cracks and stellar cracks) is mechanical damage **(Awosanya et al., 1998)**.

Mechanical damage of the egg shell caused either alone or hens is caused due to poor management practices, such as frequent collection of eggs, excessive handling of eggs, bad shape cages or cage maintenance. Egg shell strength

**Table 1** Causes of shell quality problems **(Jacob et al., 2000)**.

| Condition of egg shell | Possible causes |
|---|---|
| Odd shaped | Inherited |
| | Disease: Newcastle disease, infectious bronchitis, laryngotracheitis, egg drop syndrome 76 |
| | Age of hens: incidence is higher in older hens |
| Thin, porous or shell-less | Inheritance influences porosity and ability to produce strong shells |
| | Lack of sufficient calcium, phosphorus, manganese or vitamin $D_3$ |
| | Vitamin $D_2$ mistakenly substituted for $D_3$ |
| | Excess phosphorus consumption, especially, by older hens |
| | Ingestion of sulphanilamide (sulpha drugs) |
| | Disease: Newcastle disease, infectious bronchitis, avian influenza, egg drop syndrome 76 |
| | Hens exposed to temperature over 85-90*F |
| | Age of hens: incidence higher with older hens |
| | Premature laying of the egg |
| Rough or abnormal shell texture | Inherited |
| | Newcastle disease, infectious bronchitis |
| | Excessive use of antibiotics |
| | Excess calcium consumption by the hens |
| | Copper deficiency |
| Mottled shells | Primarily caused by high or low extremes in humidity |
| | Inherited |
| | Manganese deficiency |
| | Artificially induced |
| | White strain layers producing tinted |
| White strain layers producing tinted eggs | Primarily inherited |
| Yellow shells | Extended use of high levels of certain antibiotics |
| Tremulous or loose air cells | Newcastle disease |
| | Infectious bronchitis |
| | Rough handling of eggs |
| | Eggs stored large end down |
| Depigmented brown shell | Infectious bronchitis |
| | High stress in the flock |
| | Egg Drop Syndrome 76 |

affects health safety egg packing mass. Eggs with weak shells are more prone to rupture, cracking and subsequent microbial contamination **(Yörük et al., 2004)**.

The purpose this study was to investigate and statistically to evaluate quality of the table eggs, their damage and soiling in various age of the laying hens during the second phase of the laying cycle.

## MATERIAL AND METHODOLOGY

### *The object of research*

The objects of the research were table eggs, egg white, egg shell, damage and soiling of the eggs. The eggs were of the final laying hybrid ISA Brown reared in the non-cage system with deep litter and free range at small-scale breeding.

### *Characteristic of experimental conditions*

The laying hens were chosen for the experiment in the non-cage system of free range at small-scale conditions. The experiment was carried out with 36 pcs of laying hens. Sampling of eggs was carried out in the laying hens aged 47 – 62 weeks, every three weeks. The number of samples for the measurement and assessment was 30 pcs of eggs (Table 2).

In the breeding system with free range at small-scale conditions were secured requirements for laying hens in accordance with the Regulation of the Slovak Republic dated 11. 12. 2002 laying down minimum standards for the protection of laying hens and its complement 9. 7. 2003 to low no. 736/2002, Regulation of the Slovak Government of 9. 7. 2003 on the protection of animals kept for farming purposes, as amended low 368/2007 coll. lows and welfare principles applying the five freedoms.

Breeding facilities stall was windowless hall with deep litter (wheat straw). Right from the door on the right side of the hall were six nests. Hen house was constructed from wood Two-storey structures. In each floor there were three nests. In one nest can lay eggs six laying hens. In the middle of the hall are the whole length perches, which are constructed as to Prevent the movement of the hens below. Therefore, under the perches were placed containers. A height of 30 perches was the direction from the top container. The laying hens without restriction went out in the range from hen house. The door of hen house was opened daily at 6:00 am, and closed at 7:00 pm. Feeding and watering of the laying hens were carried out in the hen house and in the free range. The laying hens had unlimited access to feed in tubular feeder and to water in bucket watering place. The laying hens were fed with complete feed mixture, which was complemented in feeders daily. A drinking water was complemented in watering place daily. Feeding and watering equipment was handmade. Eggs were collected by hand and each day at 4:00 pm.

### *Investigated indicators*

- egg weight,
- egg white weight,
- egg shell weight,
- damage to the eggs by deformation of shape,
- damage to the eggs by ridges on the shell,
- damage to the eggs by stained dots on the shell,
- damage to the by rupture of the shell eggs and cracks
- soiling of eggs with blood,
- soiling of eggs with dung.

### *Working procedures*

An egg weight was measured on scales type KERN 440-35N, with an accuracy of 0.01 g and a maximum weight of 400 g.

Sample preparation: The egg was broken, separated the yolk and the white. The yolk placed in pre-weighed watch glass and the egg shell with membranes were washed with tap water and dried in a drying cabinet preheated to 55 °C. Yolk and shell were weighed on scales of type KERN 440-35N, with an accuracy of 0.01 g and a maximum weight of 400 g.

White weight was calculated using the formula:

$$x = \text{egg weight, g} - (\text{weight of egg yolk, g} + \text{weight of egg shell, g})$$

Damage and soiling of eggs were assessed in the laboratory of the Department of Food Hygiene and Safety. Each sample of egg was laid on white paper under the desk lamp lighting up to 100 W bulb. Investigation damage and soiling of eggs was carried out by rotating of egg at first in the equatorial plane and followed assessment of blunt and sharp egg end. There was recorded a number of damaged eggs with deformed shape, the shell ridges, dotted with different shade of colour (deviation) as staining of shell area, and with ruptured shell and the shell cracks. It was recorded also the number of eggs soiled with blood or dung (stains).

### *Statistical methods*

The obtained data were assessed according to basic statistical characteristics $\bar{x}$ = mean, SD = standard deviation and $c_v$ = coefficient of variation). Scheffe´s test at the significance level of $\alpha = 0.05$ was used to compare a difference between indicator values in the program system SAS, version 8.2.

## RESULTS AND DISCUSSION

A procedure for assessment of quality of table eggs is carried out according to certain methods, which are described and characterized in many scientific and professional works and legislative measures. By making was altered breeding system of laying hens in the European Union according to the principles of welfare, including the Slovak Republic, January 1, 2012, there is

**Table 2** Sampling schemes to measure.

| | | | | | | |
|---|---|---|---|---|---|---|
| Age of birds, week | 47 | 50 | 53 | 56 | 59 | 62 |
| Number of egg samples, pcs | 30 | 30 | 30 | 30 | 30 | 30 |
| Number of birds, pcs | 36 | 36 | 36 | 36 | 36 | 36 |

not enough unambiguous conclusions of literary knowledge founded on the experimental results. From literary knowledge it is not clearly determined, based on which indicators may be method of assessment of table eggs safety. From the existing conclusions of the various scientific and professional published works, it is known that both quality and safety are interrelated and in many works are the risk factors referred together as the quality standards. Overview of quality standards for table eggs of laying hens already in 2000 published **Jacob et al. (2000)**. These authors included among the qualitative indicators dirty stains on the shell, stuck dirt or contaminants on the shell, egg shape, and shell texture, ridges on the shell and egg shell thickness.

## Weight of eggs, white, yolk and shell

### *Egg weight*

**European Cmmission (2003)**, as well as **Council of the European Union (2006)** determined the classification of table eggs intended for marketing in the European Union by legislative measure. These are the eggs of class A or class B. In these legislative measures it is laid down that only graded eggs can be sold for the purpose of direct human consumption or sold at retail-trade.

In our experiment, we focused on the weight of the eggs, because according to **Butcher and Miles (2003), Rajkumar et al. (2009)** smaller eggs generally have a stronger shell compared to larger eggs. This fact is explained by the fact that the laying hens have a limited capacity to store calcium in shells. The result is the same amount of calcium spread over a smaller area of the smaller eggs and a larger area at a larger egg. Weight of table eggs in the experiment was 63.52 g of laying hens aged 47 weeks, which had an increasing tendency to 53 weeks of age of laying hens. After 56 weeks of age of laying hens decreased an average egg weight of 0.21 g and the end of the reporting period entered into an upward trend. Average egg weight for the whole examined period in our experiment was 64.69 g. A similar egg weight 65.46 g, **Angelovičová and Polačková (2015)** state at Moravia SSL laying hens aged 60 weeks or more 68.98 g is published in work by **Angelovičová et al. (2013)** at ISA Brown laying hens aged 61 weeks. We found an interesting fact about the average egg weight when assessing of trend according to individual weeks of age of laying hens. With increasing age of laying hens was also mild increasing of egg weight, besides the average egg weight at 56 weeks of age, when the trend of increasing values interrupted.

**Table 3** Average egg weight according to age of laying hens.

| Age of laying hens weeks | n | $\bar{x}$ (g) | SD (g) | $c_v$ (%) |
|---|---|---|---|---|
| 47 | 30 | 63.52 | ±4.41 | 6.94 |
| 50 | 30 | 64.14[a] | ±5.59 | 8.71 |
| 53 | 30 | 64.71 | ±3.89 | 6.01 |
| 56 | 30 | 64.50[b] | ±4.33 | 6.71 |
| 59 | 30 | 65.49 | ±5.81 | 8.87 |
| 62 | 30 | 65.80[a] | ±5.78 | 8.78 |
| Average egg weight for the entire period of investigation | 180 | 64.69 | | |

Note: n – number of samples, $\bar{x}$ – mean, SD – standard deviation, $c_v$ – coefficient of variation, a, b – value within a column with different superscript letter is significantly different ($p$ <0.05).

**Table 4** Average egg white weight according to age of laying hens.

| Age of laying hens weeks | n | $\bar{x}$ (g) | SD (g) | $c_v$ (%) |
|---|---|---|---|---|
| 47 | 30 | 38.21 | ±3.42 | 8.95 |
| 50 | 30 | 39.15 | ±4.19 | 10.70 |
| 53 | 30 | 39.47 | ±3.98 | 10.08 |
| 56 | 30 | 39.72 | ±2.93 | 7.,38 |
| 59 | 30 | 39.53[a] | ±3.73 | 9.44 |
| 62 | 30 | 40.70[b] | ±4.08 | 10.02 |
| Average egg weight for the entire period of investigation | 180 | 39.46 | | |

Note: n – **number** of samples, $\bar{x}$ – mean, SD – standard deviation, $c_v$ – coefficient of variation, a, b – value within a column with different superscript letter is significantly different ($p$ <0.05).

The lowest values of variation in egg weight according to the results of the standard deviation was at the laying hens aged 53 weeks (SD = ±3.89 g), which represents a variation of values according to the results of the coefficients of variation $c_v$ = 6.01%. The highest variation of values according to the results of the standard deviation was at the laying hens aged 59 weeks (SD = ±5.81 g), which represents a variation of values according to the results of the coefficients of variation $c_v$ = 8.87%. Statistically significant difference of egg weight ($p$ <0.05) according to specified age of laying hens was found between
50 to 56 weeks and 56 to 62 weeks.

### *Egg white weight*

**Abanikannda et al. (2007)** state, the egg shell quality directly depends on the egg white quality. This fact explicates that the egg white is situated under egg membranes providing a structure for storing the egg shell. We found a trend of average weight egg white by individual weeks of age of laying hens, which does not correspond to the trend of increasing values of average egg weight. The trend of white weight was interrupted at the laying hens aged 59 weeks. The average weight of the egg white over the entire follow-up period was 39.46 g.

The lowest values of variation in egg white according to the results of the standard deviation was at the laying hens aged 56 weeks (SD = ±2.93 g), which represents a variation of values according to the results of the coefficients of variation $c_v$ = 7.38%. The highest variation of values according to the results of the standard deviation was at the laying hens aged 50 weeks (SD = ±4.19 g), which represents a variation of values according to the results of the coefficients of variation $c_v$ = 10.70%. Statistically significant difference of egg weight ($p$ <0.05) according to specified age of laying hens was found between 59 to 62 weeks.

### *Egg shell weight*

We found an important fact in assessing the trend of values of the egg shell weight, depending on the age of laying hens.

Based on this fact, it can be assumed that the values of egg shell weight were not directly related to egg weight and egg white weight. It follows that the egg shell weight must be assessed comprehensively, and account must be taken of other factors. The average egg shell weight for the whole period of follow-up was 5.99 g. The lowest values of variation in egg white according to the results of the standard deviation was at the laying hens aged 47 weeks (SD = ±0.47 g), which represents a variation of values according to the results of the coefficients of variation $c_v$ = 7.64%. The highest variation of values according to the results of the standard deviation was at the laying hens aged 62 weeks (SD = ±0.71 g), which represents a variation of values according to the results of the coefficients of variation $c_v$ = 12.47%. Statistically significant difference of egg weight ($p$ <0.05) according to specified age of laying hens was found between 47 to 50 and 59 to 62 weeks.

#### *Demage and soiling of egg shell*

In terms of known knowledge about the safety of food of animal origin which published **Chukwuka et al. (2011)**, it is determined specification of products intended for human consumption, which is characterized by criteria that must be fulfilled. According to these authors, great emphasis is placed on the egg shell, which must be for eggs intended for trading visibly clean and must not contain any defects that are visible under lighting. The table eggs must not show signs of embryonic development or decay, and no blood clots. They must not be incubated. They must be processed and stored under conditions which prevent condensation of water on the surface of the egg. From above mentioned conclusions and literary knowledge is evident that a methods and indicators for assessing of the safety of table eggs are different in the published works. In our view, it is difficult to assess the safety of table eggs by risk factors of chemical, biological and physical origin, as these factors capture the essence of assessment also the quality of table eggs, whether it is chemical composition of the egg contents or shell eggs indicators. The table eggs are specific and different from other foods of animal origin. Their edible part is protected by natural packing, egg shell. Based on the known information on the prohibition of using the conventional breeding of laying hens from 2012, many authors researched alternative to conventional cages **(Abrahamsson and Tauson, 1995;**

**Table 5** Average egg shell weight according to age of laying hens.

| Age of laying hens weeks | n | $\bar{x}$ (g) | SD (g) | $c_v$ (%) |
|---|---|---|---|---|
| 47 | 30 | 6.15[a] | ±0.47 | 7.64 |
| 50 | 30 | 6.19[b] | ±0.66 | 10.66 |
| 53 | 30 | 5.97 | ±0.50 | 8.37 |
| 56 | 30 | 6.01 | ±0.56 | 9.32 |
| 59 | 30 | 5.91[a] | ±0.69 | 11.67 |
| 62 | 30 | 5.72[b] | ±0.71 | 12.41 |
| Average egg weight for the entire period of investigation | 180 | 5.99 | | |

Note: n – number of samples, $\bar{x}$ – mean, SD – standard deviation, $c_v$ – coefficient of variation, a, b – value within a column compared between 47 to 50 and 59 to 62 weeks with different superscript letter is significantly different ($p$ <0.05).

**Tauson et al., 1999; Tauson, 2002; Wall and Tauson, 2002; Wall et al., 2002; Rodenburg et al., 2005, 2008)**. The essence of research of alternative to conventional breeding had more commercial standpoint in respect of the production and the welfare of laying hens and not the quality or safety of table egg. In the same time horizon, it was published also experimental works. A research bol oriented to comparison of breeding system for laying hens in enriched cages and non-cage system in relation to hygiene, egg safety, respectively. **Wall and Tauson (2002)**, in the same time horizon, it was published also experimental works. A research bol oriented to comparison of breeding system for laying hens in enriched cages and non-cage system in relation to hygiene, egg safety, respectively. Similarly, **De Reu et al. (2005), Mallet et al. (2006)** warned of possible bacterial contamination egg shells. On the base of conclusions of published work, it can be stated that a research and risk assessment methods for table eggs remain open.

Following the above issue, we focused on research to address the safety of table eggs. We chosed the selection of individual indicators under legislation by the European Union and some published works. Already in 1998 **Awosanya et al.** reported that the demaged egg shell has a negative effect on the efficiency of the production of table eggs and overall economy of breeding of laying hens on the farm.

From this point of view it is very important attending to damage but also clean egg shell. For example, egg producers Federation of New Zealand assessed table eggs on the adopted Code **(EPF and NZFSA, 2002)** by 14 potential flaws of egg shell, which are divided into five major categories: flaws of eggs associated with the integrity of the shell, texture of shell, shape, color and cleanliness.

For the characteristics of the deformed egg shape has been one pc, representing 3.33% of the samples taken for analysis eggs at age 53 weeks of total sampled eggs for analysis. In the following 56 weeks of age there was not a deformed egg shape. The next subsequent sampling 59 weeks of age were recorded two pcs of eggs with deformed shape, i.e. 6.67%. At the last sampling egg at 62 weeks, the number of eggs with deformed shape increased to three pcs, representing 10.0% of total sampled eggs for analysis.

The sediments on the shell eggs were observed as variable ridge shapes of the shell matter. At the first sampling of eggs at age 47 weeks of laying hens were found 2 pcs of this defect, representing 6.67% of total sampled eggs. The ridges on the egg shell belong to deviations of the natural shell associated with its texture. These defects of egg shell frequently occur depending on the age of laying hens but can also be caused by other factors **(Coutts and Wilson, 1990)**.

We focused in our experiment mainly on the age factor of laying hens that was interested from aspect of clarifying the relation between ridges on the egg shell and weight of the egg, white, egg, respectively. The results of investigated ridges on the egg shell showed that there occurred in every age of laying hens. Their highest number was recorded in the age of laying hens 59 and 62 weeks (5 pcs, i.e. 16.67% of the 30 egg samples). After 59 weeks of age of laying hens was found also reduce the weight of the white and shell and in the age 62 weeks of age was reduced egg shell weight.

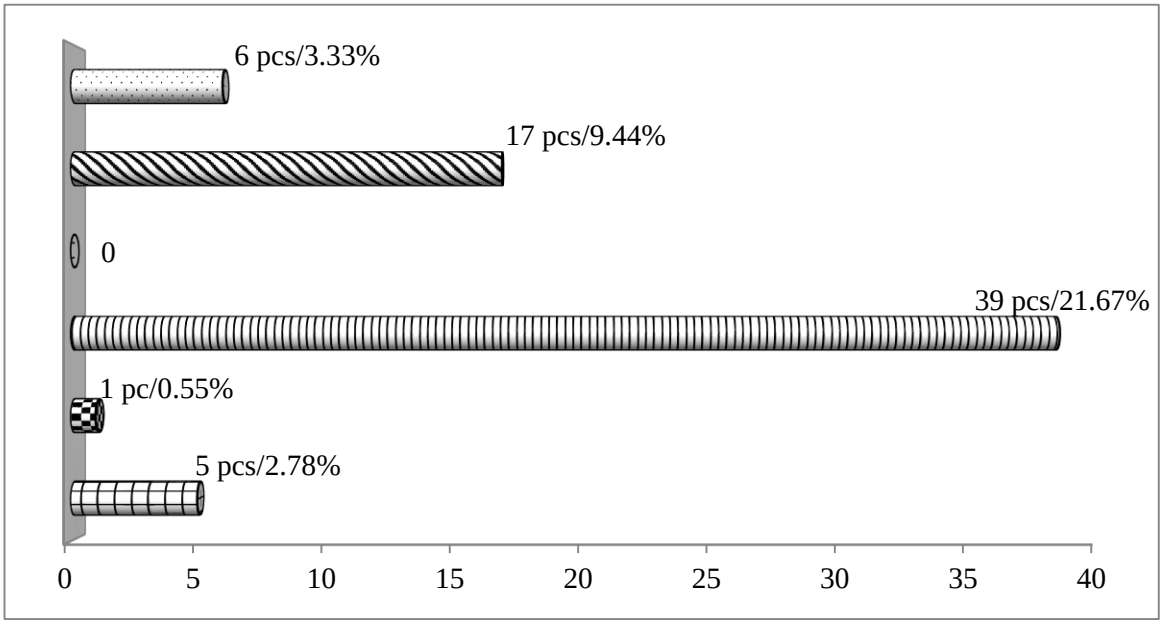


**Figure 1** The number and proportion of eggs with dirty and damaged shell for the whole period of the experiment (n = 180). Note: 6 pcs/3.33% – the number and proportion of deformed eggs, 17 pcs/9.44% – the number and proportion of eggs with ridges on the shell, 0 – the number and proportion of eggs with ruptured shell, cracks, 39 pcs/21.67% the number and proportion of eggs with dots of pigments, 1 pc/0.55% – the number and proportion of eggs with blood stains, 5 pcs/2.78% – the number and proportion of eggs with dung stains.

**Table 6** The number of eggs with dirty and damaged shell and their proportion of the number of eggs investigated according to age of laying hens (n = 30).

| Age of laying hens, weeks | 47 | | 50 | | 53 | | 56 | | 59 | | 62 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Indicator | pc | % | pc | % | pc | % | pc | % | pc | % | pc | % |
| Deformed egg shape | 0 | 0 | 0 | 0 | 1 | 3.33 | 0 | 0 | 2 | 6.67 | 3 | 10.00 |
| Ridges on the egg shell | 2 | 6.67 | 1 | 3.33 | 1 | 3.33 | 3 | 10 | 5 | 16.67 | 5 | 16.67 |
| Dots of pigments on the egg shell | 6 | 20.00 | 7 | 23.33 | 5 | 16.67 | 6 | 20.00 | 6 | 20.00 | 9 | 30.00 |
| Ruptured egg shell, cracks | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Blood stains | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3.33 | 0 | 0 |
| Dung stains | 3 | 10.00 | 0 | 0 | 0 | 0 | 1 | 3.33 | 0 | 0 | 1 | 3.33 |
| Total | 11 | 36.67 | 8 | 26.67 | 7 | 23.33 | 10 | 33.33 | 14 | 46.67 | 18 | 60.00 |

**Khan et al. (2004)** state that egg production with calcareous sediments on the shell is probably hereditary.

Currently, the consumer prefers the consumption of eggs with brown shell. Egg shell color is determined primarily by genetics of laying hens **(Fairfull and Gowe, 1990)**. The results of our experiments have shown that the occurrence of the dots on egg shell had a shade darker brown color or bright dots, especially on the ends of the egg. The occurrence of dotted eggs was recorded in each assessed age of laying hens (5 – 7 pcs, i.e. 16.67 to 23.33%), while in the last, evaluated 62 weeks of age laying hens even up to 9 pcs. These dots and their occurrence are related to the intensity of pigment deposition in the shell cuticle **(Fairfull and Gowe, 1990)**. The process of distribution of pigment in egg shell is the same as is formed by packing egg shell and therefore the cuticle. **Khan et al. (2004)** state the pigment distribution may not achieve a coherent area of the cuticle, of the entire package surface. Any factor that causes disruption to the process of synthesis and deposition of pigment in the cuticle or the ability of the epithelial cells of the pigment synthesis affects to color of the egg shell. These factors include stress according to **Gerber (2009)**. In our investigations of relations, we eliminated this factor, because for laying hens were secured all the rearing conditions under principles of welfare.

An important factor was in our experiment an age of laying hens, which **Abdullah et al. (2003)** marked also as an important factor. According to them, with the increasing age of laying hens reduces the intensity of pigment deposition in the egg shell. They reason this state that with the age of laying hens is reduced pigment synthesis. But they do not exclude even increasing of egg surface area, of the egg shell area, to which the pigment is stored. This fact is confirmed by our results especially in week 62 of age of laying hens, which was the highest occurrence of pigment dots on the shell and also these eggs had the highest average weight.

The eggs with ruptured shell or with cracks not included for direct consumption. The occurrence of such eggs with damaged shell did not occur between samples of eggs in our experiment.

Blood stains on the shell of assessed eggs which have been the object of our investigation, were rare. We found only one egg sample with soiled shell at laying hens aged 59 weeks. In this age was also found reduced weight of the egg shell and egg white. **Chukwuka et al. (2011)** note the table eggs should be visibly clean. Similarly, **Jacob et al. (2000)** reported that on the shell of table eggs may not be glued extraneous soilings or elements.

An observance of cleanliness and hygiene in rearing of laying hens is the basis of egg production management. An occurrence of egg shell with dung stains in our experiment confirms that this soiling is not connected with age of laying hens. Number 3 eggs instantly at the first sampling of eggs in hens laying hens aged 47 weeks was associated with dung dirty floors. The floor was cleaned once per day. One egg with the dirty egg shell occurred in samples taken from laying hens aged 56 and 62 weeks. According to current knowledge, it is known that hens lay eggs clean. After laying, may be dirty with dung or other impurities **(Sauter and Petersen, 1974; Nascimento and Solomon, 1991)**.

The accumulation of persistent toxic substances in the environment by human activity negatively affects the quality and safety of the egg shell. Many researchers focus their tasks of investigation to this aspect. Egg shell a good indicator for research of soiling **(Falk et al., 2006; Castilla et al., 2009a)**. Therefore, the egg shell is the center of attention of research teams primarily in terms of its characteristics **(Hunton, 1995; Carnarius et al., 1996; Massaro and Davis, 2004, 2005; Castilla et al., 2007, 2009b)**.

On the base of literary knowledge and results of our experiment, we can state that the shell is an important factor of the table egg quality and safety. With regard to the literary sources supported by experiments are poor in unambiguous conclusions, this area remains opened for further research.

## CONCLUSION

From the existing conclusions of the various scientific and professional published works, it is known that both quality and safety are interrelated and in many works are

the risk factors referred together as the quality standards. We found an important fact in assessing the trend of values of the egg shell weight, depending on the age of laying hens. Based on this fact, it can be assumed that the values of egg shell weight were not directly related to egg weight and egg white weight. Egg white creating a direct contact with the egg shell, its membranes. In connection with the new welfare conditions of rearing laying hens need to be experimentally verified:

- which indicators should form the basis for assessing the health safety of eggs,
- which should form the basis for relations between the evaluation indicators of technological quality indicators and health safety of eggs,
- or qualitative indicators eggs must be distinguished from safety indicators eggs in relation to consumer health protection.

## REFERENCES


Abdullah, A. R., Ojedapo, L. O., Adedeji, T. A., Olayeni, T. B., Adedeji, O. S. 2003. Influence of hens age on egg quality parameters in Bovans Nera black layer strain. In *Proceedings of the 28th Annual Conferences of the Nigerian Society for Animal Producton*. Cross Rivers State: University of Calabar, p. 103-103.

Abrahamsson, P., Tauson, R. 1995. Aviary systems and conventional cages for laying hens. *Acta agriculturæ Scandinavica*, vol. 45, no. 3, p. 191-203. [cit. 2015-08-24]. Available at: http://www.tandfonline.com/doi/abs/10.1080/09064709509415851

Angelovičová, M., Alfaig, E., Král, M., Tkáčová, J. 2013. the effect of the probiotics bacillus subtilis (PB6) on the selected indicators of the table eggs quality, fat and cholesterol. *Potravinarstvo*, vol. 7, no. 1, p. 80-84. http://dx.doi.org/10.5219/271

Angelovičová, M, Polačková, D. 2015. Assessment of welfare and egg production of laying hens Moravia SSL in small-scale breeding. *Potravinarstvo*, vol. 9, no. 1, p. 365-374. http://dx.doi.org/10.5219/514

Awosanya, B., Joseph, J. K., Olaosebikan, O. D. 1998. The effect of age of bird on shell quality and component yield of eggs. *Nigerian Journal of Animal Production*, vol. 25, p. 68-70.

Butcher, G. D., Miles, R. D. 2003. *Factors causing poor pigmentation of brown shelled eggs*. Florida : University of Florida [online]. [cit. 2015-08-24]. Available at: http://edis.ifas.ufl.edu/pdffiles/VM/VM04700.pdf.

Carnarius, K. M., Conrad, K. M., Mast, M. G., Macneil, J. H. 1996. Relationship of eggshell ultrastructure and shell strength to the soundness of shell eggs. *Poultry Science*, vol. 75, no. 5, p. 656-663. http://dx.doi.org/10.3382/ps.0750656

Castilla, A. M., Herrel, A., Díaz, G., Francesch, A. 2007. Developmental stage affects eggshell breaking strength in two ground-nesting birds: the partridge (*Alectoris rufa*) and the quail (*Coturnix japonica*). *Journal of Experimental*, vol. 307A, no. 8, p. 471-477. http://dx.doi.org/10.1002/jez.400

Castilla, A. M., Martínez de Aragón, J., Herrel, A., Møller, S. 2009a. Eggshell thickness variation in red-legged partridge (*Alectoris rufa*) from Spain. *The Wilson Journal of Ornithology*, vol. 121, 2009a, p. 167-170. http://dx.doi.org/10.1676/08-024.1

Castilla, A. M., Herrel, A., Van Dongen, S., Furio, N., Negro, J. 2009b. Determinants of egg shell strength in endangered raptors. *Journal of Experimental Zoology*, vol. 311A, 2009b, p. 303-311. http://dx.doi.org/10.1002/jez.532 PMid:19267399

Chukwuka, O. K., Okoli, N. J., Okeudo, A., Udedibie, B. I., Ogbuewu, I. P., Aladi, N. O., Iheshiulor, O. O. M., Omede, A. A. 2011. Egg Quality Defects in Poultry Management and Food Safety. *Asian Journal of Agricultural Research*, vol. 5, no. 1, p. 1-16. http://dx.doi.org/10.3923/ajar.2011.1.16

*Council Directive 1999/74/EC on 19 July 1999 laying down minimum standards for the protection of laying hens. Off. Journal European Communities L203, p. 53-57.*

*Council Regulation (EC) No. 1028/2006 on marketing standards for eggs. Official Journal of the European Union L 186, 7 July 2006, p. 1-5.*

Coutts, J. A.,Wilson, G. C. 1990. *Egg Quality Handbook*. Brisbane : Department of Primary Industries. 56 p. ISBN 10: 0724232222.

De Reu, K., Grijspeerdt, K., Heyndrickx, M., Zoons, J., De Baere, K., Uyttendaele, M., Debevere, J., Herman, L. 2005. Bacterial eggshell contamination in conventional cages, furnished cages and aviary housing systems. *British Poultry Science*, vol. 46, no. 2, p. 149-155. http://dx.doi.org/10.1080/00071660500065359 PMid:15957434

EPF and NZFSA, 2002. Egg producers federation of New Zealand (Inc) code of practice (Includes Requirements for Risk Management Programs) [online]. [cit. 2015-08-24]. Available at: http://www.nzfsa.govt.nz/consultation/egg-cop/discussion-paper/ egg-cop-ch1.pdf.

*Commission Regulation (EC) No 2295/2003 of 23 December 2003 introducing detailed rules for implementing Council Regulation (EEC) No 1907/90 on certain marketing standards for eggs. Official Journal of the European Union L 340,* 24 December 2003, p. 16-34.

Fairfull, R. W., Gowe, R. S. 1990. Genetics of Egg Production in Chickens. In Crawford, R. D.: *Poultry Breeding and Genetics*. New York : Elsevier., vol. 70, p. 963-969.

Falk, K., Mřller, S., Mattox, W. 2006. A long-term increase in eggshell thickness of Greenlandic peregrine falcons Falco peregrinus tundrius. *Science of the Total Environment*, vol. 355, p. 127-134. http://dx.doi.org/10.1016/j.scitotenv.2005.02.024 PMid:15885749

Gerber, N. 2009. *Factors affecting egg quality in the commercial laying hen*: A review. [online]. [cit. 2013-11-28]. Available at: http://eggfarmers.org.nz/eggfarmers/wp-content/uploads/2012/04/factors_affecting_egg_quality.pdf

Hunton, P. 1995. Understanding the architecture of the egg-shell. *World's Poultry Science Journal*, vol. 51, no. 2, p. 141-147. http://dx.doi.org/10.1079/WPS19950009

Jacob, J. P., Miles, R. D., Mather, F. B. 2000. *Egg quality*. Florida : University of Florida, 11 p. (Bulletin, PS24).

Khan, M. K. I., Khatun, M. J., Kibria, A. K. M. G. 2004. Study the quality of eggs of different genotypes of chickens under semi-scavenging system at Bangladesh. *Pakistan Journal of Biological Sciences*, vol. 7, no. 12, p. 2163-2166. http://dx.doi.org/10.3923/pjbs.2004.2163.2166

Mallet, S., Guesdon, V., Ahmed, A. M. H., Nys, Y. 2006. Comparison of eggshell hygiene in two housing systems: Standard and furnished cages. *British Poultry Science*, vol. 47, no. 1, p. 30-35. http://dx.doi.org/10.1080/00071660500468132 PMid:16546794

Massaro, M., Davis, L. S. 2004. The influence of laying date and maternal age on eggshell thickness and pore density in yellow-eyed penguins. *Condor*, vol. 106, no. 3, p. 496-505. http://dx.doi.org/10.1650/7395

Massaro, M., Davis, L. S. 2005. Differences in egg size, shell thickness, pore density, pore diameter and water vapour conductance between first and second eggs of snares penguins *Eudyptes robustus* and their influence on hatching asynchrony. *Ibis*, vol. 147, no. 2, p. 251-258. http://dx.doi.org/10.1111/j.1474-919x.2005.00379.x

Nascimento, V. P., Cranstoun, S., Solomon, S. E. 1992. Relationship between shell structure and movement of *Salmonella enteritidis* across the eggshell wall. *British Poultry Science*, vol. 33, no. 1, p. 37-48. http://dx.doi.org/10.1080/00071669208417442 PMid:1571806

Rajkumar, U., Sharma, R. P., Rajaravindra, K. S., Niranjan, M., Reddy, B. L. N., Bhattacharya, T. K., Chatterjee, R. N. 2009. Effect of genotype and age on egg quality traits in naked neck chicken under tropical climate from India. *International Journal Poultry Science*, vol. 8, no. 12, p. 1151-1155. http://dx.doi.org/10.3923/ijps.2009.1151.1155

*Regulation of the Slovak Republic dated 11. 12. 2002 laying down minimum standards for the protection of laying hens to low no. 736/2002.*

*Regulation of the Slovak Government of 9. 7. 2003 on the protection of animals kept for farming purposes as amended low no. 368/2007 coll. lows.*

Rodenburg, T. B., Tuyttens, F., De Reu, K., Herman, L., Zoons, J., Sonck, B. 2005. Welfare, health and hygiene of laying hens housed in furnished cages and in alternative housing systems. *Journal of Applied Animal Welfare Science*, vol. 8, no. 3, p. 211-226. http://dx.doi.org/10.1207/s15327604jaws0803_5 PMid:16468949

Rodenburg, B., Tuyttens, F., De Reu, K., Herman, L., Zoons, J., Sonck, B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: An on-farm comparison. *Animal Welfare*, vol. 17, no. 4, p. 355-361.

Sauter, E. A., C. F. Petersen, 1974. The effect of egg shell quality on penetration by various salmonellae. *Poultry Sciences*, vol. 53, p. 2159-2162. http://dx.doi.org/10.3382/ps.0532159 PMid:4618346

Tauson, R., Wahlström, A., Abrahamsson, P. 1999. Effect of two floor housing systems and cages on health, production, and fear response in layers. *Journal of Applied Poultry Research*, vol. 8, no. 2, 1999, p. 152-159. http://dx.doi.org/10.1093/japr/8.2.152

Tauson, R. 2002. Furnished cages and aviaries: Production and health. *World's Poultry Science Journal,* vol. 58, no. 01, p. 49-63.

USDA Food Safety and Inspection Service. 2013. Egg Products and Food Safety. [online]. [cit. 2013-11-28]. Available at: http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/egg-products-preparation/egg-products-and-food-safety/ct_index

Wall, H., Tauson, R. 2002. Egg quality in furnished cages for laying hens. Effects of cracked reduction measures and hybrid. *Poultry Science*, vol. 81, no. 3, p. 340-348. http://dx.doi.org/10.1093/ps/81.3.340 PMid:11902409

Wall, H., Tauson, R., Elwinger, K. 2002. Effects of nest design, passages and hybrid on use of nest and production performance of layers in furnished cages. *Poultry Science*, vol. 81, no. 3, p. 333-339. http://dx.doi.org/10.1093/ps/81.3.333 PMid:11902408

Yörük, M. A., Gul, M., Hayirli, A., Karaoglu, M. 2004. Laying performance and egg quality of hens supplemented with sodium bicarbonate during the late laying period. *International Journal Poultry Sciences*, vol. 3, no. 4, p. 272-278. http://dx.doi.org/10.3923/ijps.2004.272.278

**Contact address:**

prof. Ing. Mária Angelovičová, Ph.D., Slovak University of Agriculture in Nitra, Faculty of Biotechnology and Food Sciences, Department of Hygiene and Food Safety, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: maria.angelovicova@uniag.sk.

Bc. Lucia Ševčíková, Slovak University of Agriculture in Nitra, Faculty of Biotechnology and Food Sciences, Department of Hygiene and Food Safety, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: sevcikova-lucia@centrum.sk.

doc. Ing. Marek Angelovič, Slovak University of Agriculture in Nitra, Faculty of Enginnering, Department of Machinery and Production Systems, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: marek.angelovic@uniag.sk.