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Effect of storage period on the quality of table eggs

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ABSTRACT

The research aim was to determine effect of storage period (measured on the 1st day and 28th day) on the quality of conventional table eggs and omega-3 eggs. The research was carried out on 120 eggs, of which 60 were conventional and 60 were produced within omega-3 production system. Research results showed that the storage period of conventional eggs significantly affected (P<0.05) increase of albumen and yolk pH, as well as aging rate, while reducing the values of albumen height, HU, yolk color and value number. Analysis of external and internal quality of omega-3 eggs indicated that the storage period significantly affected (P<0.05) increase of albumen and yolk pH and aging rate, and reduced values for egg shell strength and thickness, albumen height, HU, and value number of stored eggs. Lipid oxidation was significantly higher in eggs stored for 28 days at 4 °C if compared to fresh eggs (P<0.05).
(Keywords: quality, eggs, omega-3, TBARS)

INTRODUCTION

Changes in yolk and albumen occur during storage of eggs, initiating hydrolytic process of protein degradation and lipid degradation. *Gajčević* (2010) stated that lipid peroxidation referred to oxidative degradation of lipids in cells. Lipid peroxidation is catalyzed by hemic and non-hemic iron. Dissociation of LOOH affects accumulation of short-chain final peroxidation products, such as aldehydes and hydrocarbons, which are responsible for unpleasant odor of oxidized fat (*Adams*, 2003). Lipids consist of different molecules, such as triglycerides, free fatty acids, xanthophylls, carotenes, vitamins and phospholipids. Their common characteristic is a molecule with a long chain of carbon atoms being connected with many double bonds. These double bonds between atoms make lipids extremely sensitive to oxidation. In the process of oxidation, lipids lose some nutritive characteristics. Fats and oils become rancid, vitamins reduce their biological value and pigments lose color. This affects the decrease of nutritive value and sensory characteristics of a product.

The aim of our research was to investigate effect of storage period (1^{st} and 28^{th} day) on qualitative indicators of conventional and omega-3 eggs.

MATERIAL AND METHODS

Omega-3 eggs (n=60) and conventional eggs (n=60) were used for the purpose of analyzing effect of storage period on quality of table eggs. Quality of eggs was determined one day after collecting eggs and on the 28^{th} day of storing eggs in refrigerator at +4°C. The research was conducted on Tetra SL genotype hens which were in the 40^{th} week of production. Hens were fed with different mixtures, one group with conventional feed and another with modified feed (which contains 5% oil mixture – soybean, rapeseed, linseed and fish oil). Analyzed indicators of external quality of eggs were: egg weight, shell strength and thickness, shell weight. Analyzed internal egg quality indicators were: weight of albumen and yolk, yolk color, albumen height, Haugh units, pH of albumen and pH of yolk, refraction of albumen and yolk, which values were used for calculation of value number (VN) and aging rate (AR) by the following expressions: VN = 1000 · ($\eta_ž$–η_b); where $\eta_ž$= *yolk refraction index*; η_b = *albumen refraction index* and AR = 1000 · (1,4184–$\eta_ž$); where 1.4184=*fracture index of standard yolk-referential value*; $\eta_ž$= *yolk refraction index* (*Janke and Jirka*, 1934).

Egg shell strength was measured by the Eggshell Force Gauge Model-II device. Thickness of shell was measured in its middle by electronic micrometer, precision of 0.001 mm. Yolk color, HU and albumen height were measured by the Egg Multi-Tester EMT-5200 device. Albumen and yolk pH value were measured by the pH meter MP 120, refraction of albumen and yolk was measured by automatic device Refracto 30PX. Lipid oxidation was determined on 40 yolks (20 fresh and 20 stored), according to modified method of *McDonald and Hultin* (1987) and *Botsoglou et al.* (1994). Yolks weighed into a test tube were mixed with 10% trichloroacetic acid (1w:3v), homogenized and centrifuged at 10000 rpm for 10 minutes at 4 °C. Supernatant was then mixed with solution of thiobarbituric acid. Tubes were closed and placed into a water bath at 90 °C for 30 minutes. Distilled water was added after cooling and mixture was then centrifuged at 6000 rpm for 5 minutes at 4 °C. The content of colored product that occurred as a reaction of lipid peroxidation with thiobarbituric acid was measured spectrophotometric at 534 nm. Obtained results of all analyses on eggs were processed in Statistica 7.1 (*StatSoft, Inc*., 2007), and presented in tables and graphs along with discussions and conclusions. Statistical indicators referred to arithmetic mean ($\bar{x}$) and error of the mean ($s\bar{x}$). Testing of significance of differences for egg quality was done by the t-test. Calculated values were compared with theoretical value at a significance level of P<0.05.

RESULTS AND DISCUSSION

Table 1 overviews results related to weights of conventional eggs and their main parts, both fresh and stored for 28 days at +4 °C. As presented, storage period had effect (P<0.05) on egg weight (67.46 g and 65.85 g) and albumen weight (41.12 g and 39.96 g), while values of yolk weight (15.53 g and 15.78 g) and shell weight (7.68 g and 7.61 g) for both fresh and stored eggs were similar (P>0.05).

Table 1

Weight of conventional eggs and main parts ($\bar{x} \pm s_{\bar{x}}$)

Indicator, g	Fresh (n=30)	Stored* (n=30)
Weight of eggs	67.46 ± 0.44^a	65.85 ± 0.43^b
Weight of albumen	41.12 ± 0.30^a	39.96 ± 0.29^b
Weight of yolk	17.75 ± 0.21	17.54 ± 0.25
Weight of shell	8.58 ± 0.11	8.29 ± 0.11

*28 days in refrigerator at +4 °C; $\bar{x}$ = mean value; $s_{\bar{x}}$= error of the mean; numbers in rows marked [a,b]differ statistically (P<0.05)

Table 2 shows results of storage period affecting external and internal quality of conventional eggs. It is obvious that storage period did not affect strength and thickness of shell in conventional eggs (P>0.05). However, storage period of conventional eggs had statistically significant (P<0.05) effect on values albumen height, HU, yolk color and VN. Values of these indicators were reducing along with storage duration. Albumen height reduced from 6.94 mm to 6.16 mm, HU reduced from 80.80 to 75.06, yolk color reduced from 8.70 to 7.86, and VN from 63.26 to 60.50. Conventional eggs exhibited statistically significant effect of storage period on the increase of pH in albumen, pH in yolk and AR. Values of pH in albumen increased from 8.66 to 9.01, pH in yolk increased from 5.99 to 6.06. AR increased from 0.933 to 1.90.

Table 2

External and internal quality indicators conventional eggs ($\overline{X} \pm s_{\overline{X}}$)

Indicator	Fresh (n=30)	Stored* (n=30)
Strength of shell, kg/cm^2	3.100±0.11	3.160±0.10
Thickness of shell, mm	0.409±0.007	0.406±0.005
Albumen height, mm	6.94±0.17^a	6.16±0.23^b
Haugh units	80.80±1.16^a	75.06±1.89^b
Yolk color	8.70±0.08^a	7.86±0.10^b
pH of albumen	8.66±0.02^b	9.01±0.01^a
pH of yolk	5.99±0.01^b	6.06±0.01^a
AR	0.933±0.20^b	1.90±0.27^a
VN	63.26±0.29^a	60.5±0.85^b

*28 days in refrigerator at +4 °C; $\overline{X}$ = mean value; $s_{\overline{X}}$= error of the mean; numbers in rows marked ^{a,b}differ statistically (P<0.05)

Table 3 presents results of comparing weights of fresh and stored omega-3 eggs and their main parts. It is obvious that storage period had effect (P<0.05) on albumen weight, meaning that storage duration of eggs affected reduction of albumen weight (from 37.24 g to 36.19 g). Values for weights of eggs, yolk and shell in both fresh and stored omega-3 eggs were similar (P>0.05).

Table 3

Weight of main parts of n-3 PUFA eggs ($\overline{X} \pm s_{\overline{X}}$)

Indicator, g	Fresh (n=30)	Stored* (n=30)
Weight of eggs	60.46±0.35	59.59±0.37
Weight of albumen	37.24±0.28^a	36.19±0.29^b
Weight of yolk	15.53±0.19	15.78±0.14
Weight of shell	7.68±0.07	7.61±0.07

*28 days in refrigerator at + 4°C; $\overline{X}$ = mean value; $s_{\overline{X}}$= error of the mean; numbers in rows marked ^{a,b}differ statistically (P<0.05)

Table 4 overviews results referring to effect of storage period on external and internal quality of omega-3 eggs. Presented results indicate that storage period did not have effect on yolk color. Fresh omega-3 eggs had statistically significantly higher shell strength and thickness than stored omega-3 eggs (3.312 kg/cm^2 and 0.377 mm, i.e. 2.981 kg/cm^2 and 0.365 mm, respectively).

Table 4

External and internal quality indicators n-3 PUFA eggs ($\bar{X} \pm s_{\bar{x}}$)

Indicator	Fresh (n=30)	Stored* (n=30)
Strength of shell, kg/cm^2	3.312±0.06^a	2.981±0.09^b
Thickness of shell, mm	3.77±0.002^a	0.365±0.002^b
Albumen height, mm	7.09±0.15^a	6.19±0.18^b
Haugh units	83.95±0.93^a	77.97±1.28^b
Yolk color	12.90±0.12	13.10±0.10
pH in albumen	8.90±0.02^b	9.08±0.01^a
pH in yolk	6.00±0.01^b	6.12±0.01^a
AR	0.86±0.35^b	1.86±0.34^a
VN	63.7±0.69^a	60.13±0.50^b

*28 days in refrigerator at +4 °C; $\bar{X}$ = mean value; $s_{\bar{x}}$= error of the mean; numbers in rows marked ^{a,b}differ statistically (P<0.05)

Storage of omega-3 eggs had statistically significant effect also on albumen height, HU and VN, meaning that albumen height was reduced from 7.09 mm to 6.19 mm, HU were lowered from 83.95 to 77.97 and VN was lowered from 63.70 to 60.13. Furthermore, storage period significantly affected (P<0.05) increase of values of albumen pH (from 8.90 to 9.08), yolk pH (from 6.00 to 6.12) and AR (from 0.86 to 1.86). Food has limited shelf life, which primarily depends on food type and storage conditions. Due to poor natural defense barrier, eggs are considered as a foodstuff with limited storage period. According to the Regulations on the quality of eggs (Official Journal No. 115/06 and 76/08), eggs can be placed on market for 28 days under certain storage conditions (in cooling shelves at a temperature up to +5 °C). Freshness of eggs is associated with their quality and affected by storage period (measured in days), as well as by storage conditions (temperature and relative air humidity). Freshness of eggs is counted from the moment of laying until the moment of their use. Every egg producer intends to keep eggs fresh as long as possible, i.e. to preserve indicators of egg freshness for a longer period of time (high values of HU, albumen height, albumen pH, etc.). Intensity of lipid peroxidation in egg yolks is one of the indicators of egg freshness. Higher values of MDA µg/g in samples indicate that oxidation is more intensive and that freshness of eggs decreases. Table 5 shows intensity of lipid peroxidation in egg yolks, both of conventional eggs and omega-3 eggs. It is evident that the storage period of eggs had statistically significant effect on lipid oxidation in egg yolks (P<0.05).

Table 5

Lipid oxidation in yolks of fresh and stored conventional and omega-3 eggs

Indicator	Conventional eggs ($\bar{X} \pm s_{\bar{X}}$)		Omega-3 eggs ($\bar{X} \pm s_{\bar{X}}$)	
	Fresh	Stored*	Fresh	Stored*
µg MDA/g	0.597±0.01^b	0.709±0.02^a	0.510±0.03^b	0.657±0.02^a

*28 days in refrigerator at +4 °C; $\bar{x}$ = mean value; $s_{\bar{x}}$= error of the mean; numbers in rows marked ^{a,b}differ statistically significantly at P<0.05

The value of MDA in conventional eggs fluctuated from 0.597 µg/g for fresh eggs to 0.729 µg/g for eggs stored for 28 days in refrigerator at +4°C. MDA in fresh omega-3 egg yolks was 0.510 µg/g, while in stored eggs it raised to 0.657 µg/g. Strength of brown egg shell was from 3.85 to 4.10 kg/cm^2 (www.isapolutry.com, 2007). Thickness of egg shell varied in dependence on egg weight (*Casiraghi et al.*, 2005). *Şekeroğlu and Altuntaş* (2009) determined statistically significantly ($P<0.05$) thicker shell for medium-weighed eggs (0.400 mm), while the thinnest shell was marked in extra-large eggs (0.382 mm). According to *Kralik et al.* (2006), optimum shell thickness ranges from 0.330 to 0.340 mm. Analysis of our results and comparison with the above mentioned values for shell thickness led to conclusion that values obtained for both examined groups of eggs (conventional and omega-3) in both measurements (fresh and stored eggs) were within the optimum interval, while values referring to shell strength were slightly below recommended values. Conventional eggs exhibited less weight, as well as less shell thickness of eggs stored at +4 °C for 28 days if compared to fresh eggs, which correlates to statements of *Farooq et al.* (2001), *Zita et al.* (2009), *Aygun and Yetisir* (2010), *Moreki et al.* (2011). Omega-3 stored eggs weighed less, but had thicker shell, which was not correlating to results of above mentioned authors. It is assumed that observed difference in shell thickness of stored eggs in comparison to fresh conventional eggs (0.365 mm and 0.377 mm, respectively; $P<0.05$) and of omega-3 eggs (3.160 mm and 3.100 mm, respectively; $P>0.05$) does not correlate with storage period of eggs. It is to conclude that there is a positive correlation between egg weight and shell thickness. Furthermore, it is presumed that values for shell strength, which are slightly lower than optimum, are not resulting from a storage period, but are rather a consequence of other factors, such as age of hens and feeding treatment (*Akyurek and Okur*, 2009). Storage period and temperature are among the most important factors to influence albumen quality and HU values. These values are determined on the basis of total egg weight and height of thick albumen. By storing eggs, structure of albumen is changing and it starts to disperse, causing its height to reduce, and consequently its HU value to decrease. According to specification for the Egg multi tester device, which was applied in measuring HU, values were classified into four freshness categories, where the freshest eggs had HU value above 72 and were marked as AA. If comparing our results with device specification values, it was concluded that investigated eggs (both conventional and omega-3 eggs) were of best freshness and met requirements of the Regulations on quality of eggs. Referring to the area of the Republic of Croatia, measured values for yolk color of table eggs produced by hens in cages range on average from 12.76–13.08 (*Kralik* et al., 2006). As expected, there are statistically significantly lower HU values and albumen height in both stored conventional and omega-3 eggs. This can be explained by the fact that storage of eggs was causing water evaporation and loss of CO_2 from albumen, depending on temperature and relative humidity during storage, due to which stored eggs exhibited lower values of albumen height and Haugh units than fresh eggs. For the same reasons (loss of CO_2), values of albumen and yolk pH were increased during storage of eggs. *Samli et al.* (2005) reported pH values of 7.47 for fresh albumen and 5.75 for fresh yolk, while eggs stored for 2 hours at a temperature of +5 °C exhibited albumen pH of 7.99, and yolk pH of 5.9. These values gradually increase during storage period. Storage period and storage conditions may affect changes in nutritive and sensory quality of food, and lipid oxidation can negatively influence its taste and smell. If a product is enriched with omega-3 fatty acids, lipid oxidation can be more intensive because of a larger portion of unsaturated fatty acids, which are susceptible to oxidation. Determination of *thiobarbituric acid reactive* substances (TBARS) indicates the extent of oxidation for various fatty acids. Lipid oxidation increases in proportion to increase of MDA concentration in analyzed sample. Our results were in accordance with results published by *Shahryar et al.* (2010), who also pointed out that MDA increased in proportion to egg storage period. They also stated that lipid oxidation was influenced not only by egg storage period, but also by hens' feeding treatment and content of omega-3 PUFA in eggs.

CONCLUSIONS

Research into effect of storage period of eggs (measured on 1st and 28th day) on the quality of conventional and n-3 PUFA eggs resulted in conclusion that storage period of conventional eggs significantly increased ($P<0.05$) albumen pH (from 8.66 to 9.01), yolk pH (from 5.99 to 6.06) and AR (from 0.933 to 1.90), while reducing values for albumen height (from 6.94 mm to 6.16 mm), HU (from 80.80 to 75.06), yolk color (from 8.70 to 7.86) and VN (from 63.26 to 60.50). Analysis of external and internal quality of omega-3 eggs proved that storage period significantly affected ($P<0.05$) increase of albumen pH (from 8.90 to 9.08), yolk pH (from 6.00 to 6.12) and AR (from 0.86 to 1.86), while causing reduction of the following values: shell strength (from 3.312 kg/cm^2 to 2.981 kg/cm^2) and shell thickness (from 0.377 mm to 0.365 mm), albumen height (from 7.09 mm to 6.19 mm), HU (from 83.95 to 77.97) and VN (from 63.7 to 60.13). Both conventional and omega-3 eggs stored for 28 days at +4 °C exhibited statistically significantly more intensive oxidation than fresh eggs of respective groups ($P<0.05$).

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