Original paper

EFFECT OF VITAMIN E, LUTEIN, SELENIUM AND OIL MIXTURE ADDED TO FEED AND COOKING LENGTH ON YOLK COLOR AND EGG QUALITY

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Abstract

The aim of this research was to determine the quality of eggs laid by Tetra SL hens fed standard diet (B) or diet supplemented with 100 mg vitamin E/kg+200 mg/kg lutein+0.5 mg/kg selenium+5% oil mixture (BK). The effect of treatment was determined for yolk color values ($P<0.001$), which were more intense in the BK group (14.35) than in the B group (12.20). Other egg quality indicators (egg mass, portions of albumen, yolk and shell, Haugh units, albumen height, egg shell thickness and strength, pH values of albumen and yolk) exhibited no statistically significant differences ($P>0.05$). However, the treatment had statistically significant effect ($P<0.001$) on yolk color values for fresh eggs (B=12.00 and BK=14.42), as well as for eggs cooked for 7 minutes (B=9.14 and BK=13.00) and for 10 minutes (B=7.28 and BK=8.42). There was statistically significant effect of treatment, cooking length and their interaction on yolk lightness (L*). This value increased in dependence on cooking length (treatment B) and consequently, for the same yolks, intensity of redness (a*) was decreased, while intensity of yolk lightness (L*) in BK treatment was varying. The L* value decreased for eggs cooked for 7 minutes, but increased significantly for eggs cooked for 10 minutes, if compared to fresh eggs ($P<0.001$). The values of egg yolk lipid oxidation (TBARS) measured for fresh eggs (B=0.735 µg MDA/g and BK 0.745 µg MDA/g) and stored eggs (B=0.778 µg MDA/g and BK=0.805 µg MDA/g) were equal for both examined groups ($P>0.05$).

Key words: *lutein, oil mixture, selenium, vitamin E, yolk color*

Introduction

Lipids are the main ingredients of egg yolks (Ahn et al., 1997). Stability and content of lipid fraction affect the quality and sensory traits of eggs (Franchini et al., 2002.). Poultry feeds should contain more plant oils and should be supplemented with antioxidants that protect poultry and poultry meat and eggs from oxidation (Barroeta, 2007). Many research studies proved that higher concentration of PUFA in eggs supported lipid peroxidation and negatively influenced sensory traits and quality of eggs (Grashorn, 2005; Mohiti-Asli et al., 2008). Therefore, poultry feed is supplemented with antioxidants, such as vitamin E, selenium and lutein. Enriching eggs with omega-3 fatty acids combined with abovementioned antioxidants have several advantages. Vitamin E, lutein and selenium protect DHA from oxidation during absorption and metabolism, thus preventing occurrence of unfavorable "fishy" taste. Yolk lipids are necessary for efficient absorption of vitamin E and lutein in human digestive system (Van het Hoff, 2000). Interaction between lutein and vitamin E and phospholipids results in increased yolk antioxidative

potential, which has positive effects on preservation of egg freshness during storage. Selenium, as a part of antioxidative enzyme glutathione peroxidase, protects intestine membrane from lipid oxidation during digestion of DHA (Surai and Sparks, 2001). Besides antioxidative effects, lutein is also a natural pigment and different studies indicated that yolk color in table eggs was an important trait from a viewpoint of consumers (Hernandez et al., 2000; Roberts, 2004). Since it is known that carotenoids cannot be produced by animals, their intake into the organism is necessary through feed. They are stored in fatty tissue, and in egg yolk, therefore adding of some kind of food colorant to the feed is necessary. The aim of this research was to determine the effect of treatment (supplementation of various oils in hens' feed combined with three antioxidants) and the cooking length on yolk color and quality of eggs.

Materials and methods

The research was carried out on 120 hens of the Tetra SL hybrid that lay eggs of brown shell color. Experimental period lasted for 5 weeks, and hens were 40 weeks old at the beginning of experiment. The groups B and BK were formed, differing only in the treatment. The B group was fed standard diet for laying hens, while the BK group was fed diet supplemented with 100 mg/kg vitamin E+200 mg/kg lutein+0.5mg/kg Se+5% oil mixture. Each group consisted of 12 cages with 5 hens in each. Analysis of external and internal quality of fresh table eggs was determined on 40 eggs of the L class. The following external egg quality indicators were analyzed: egg mass, egg shell strength and thickness, egg shell mass. Assessed internal egg quality indicators were: mass of albumen and yolk, color of yolk, albumen height, Haugh units (HU), pH values of albumen and yolk. Portions of main parts in egg were also calculated. Mass of egg and its main parts (albumen, yolk and shell) was determined on the scales PB 1502-S. Egg shell strength was measured in the Eggshell Force Gauge Model-II device. Thickness of egg shell was measured by electronic micrometer providing accuracy of 0.001 mm in the middle of egg shell. HU and albumen height were determined by the Egg Multi-Tester EMT-5200. Values of pH of albumen and yolk were measured by the pH meter MP 120. Yolk color was determined by using DSM Color Fan (values were presented in the table as La Roche; DSM Nutritional Products, Basel, Switzerland). Other indicators of yolk color (L*, a* and b*) were measured by Minolta CR-300 colorimeter (Minolta, Osaka, Japan). A total of 28 yolks (14 fresh and 14 stored) was used to determine oxidation of lipids, according to the modified methods of McDonald and Hultin (1987) and Botsoglou et al. (1994). Eggs were stored for 28 days in a refrigerator at +4°C. Research results were processed by using Statistica for Windows, version 12.0 (StatSoft Inc., 2013). Data processing was completed by applying GLM procedure for calculation of analysis of variance. Examined factors referred to the treatments (B and BK) and the length of cooking (0, 7 and 10 minutes). Differences between groups were determined by post-hoc analysis using the Fisher's LSD test.

Results and discussion

The Table 1 presents the results of fresh egg quality. According to the egg mass of both examined groups, and following the Regulations on egg quality (OJ 115/06 and 76/08), all eggs belong to the market class L (B=68.28 g and BK=67.13 g; P>0.05). Both examined groups of eggs had similar portions of main parts (albumen= 61.92% and 62.30%, yolk 25.69% and 25.27% and egg shell 12.34% and 12.42%, respectively), meaning that treatments did not have any effect on stated indicators. The HU values were higher in the

treatment B than in the treatment BK (78.48 and 76.75, respectively), however, obtained difference was not statistically significant. Specification for the device Egg multi tester used for measuring of HU values above 72 refer to the freshest eggs (extra fresh). Referring to freshness, when comparing values of HU obtained in our experiment with values from specification, it was noticed that eggs in both groups were above lower level for extra fresh eggs, which is also in line with the provisions of the Regulations on egg quality (OJ 115/06 and 76/08).

Table 1. *Indicators of fresh egg quality*

Characteristics	B	BK	SEM	Probability
Egg weight (g)	68.28	67.13	0.710	NS
Albumen percentage (%)	61.92	62.30	0.312	NS
Yolk percentage (%)	25.69	25.27	0.244	NS
Shell percentage (%)	12.34	12.42	0.188	NS
Yolk color (La Roche)	12.20^{b}	14.35^{a}	0.134	<0.001
Haugh units	78.48	76.75	1.927	NS
Height albumen (mm)	6.53	6.52	0.261	NS
Shell thickness (mm)	0.407	0.404	0.008	NS
Shell breaking strength (kg/cm^2)	3.179	2.917	0.135	NS
pH albumen	8.65	8.37	0.103	NS
pH yolk	5.96	5.97	0.015	NS

*B=standard laying hens' mixture; BK=100 mg/kg vit. E+200 mg/kg lutein+0.5mg/kg Se+5% oil mixture.
NS- non-significant. Values in columns marked by different exponents ^{a,b} differ statistically.

More stronger and thicker egg shell was observed in the group B then in BK (3.179 kg/cm^2 and 0.407 mm, compared to 2.917 kg/cm^2 and 0.404 mm, respectively), however, there was no statistically significant influence of the treatment (P> 0.05). The study on effects of egg mass on some indicators of egg quality, Şekerog˘lu and Altuntaş (2009) stated that eggs of medium weight had the thickest shell (0.400 mm), while the thinnest shell was determined for eggs classified as extra-large (0.382 mm). The longer hens remain in production, the thinner egg shell will become. The optimum thickness of shell of brown eggs ranges from 0.330 to 0.340 mm (Kralik et al., 2008). Comparison of our results with the above mentioned values led to conclusion that the thickness of egg shell was above the optimal values in both examined groups. Statistically significantly (P<0.001) more intensive color of fresh yolk was determined in the BK treatment (14.35) than in the B treatment (12.20). It was assumed that such differences in egg yolk color were caused primarily by lutein, which was supplemented in feed of the BK group. Lutein belongs to the group of fat-soluble carotenoids, which are also known as xanthophylls (Yeum and Russell, 2002). Lutein is primarily used in chicken feed as a natural pigment to intensify yellow color of yolk, but later on, its antioxidant activity was also proven (Lim et al., 1992). Jang et al. (2014) also stated that supplementation of lutein in hens' feed significantly affected egg yolk color (P<0.05). Since the vitamin E was also added to feed of the BK group its influence shall be also considered because it can also intensify the egg yolk color (Carrillo-Dominguer et al., 2012). Values of pH in albumen and yolk were similar for both groups of eggs (P>0.05). It was determined that the treatment and the length of cooking had statistically significant effect on intensity of egg yolk color as measured by DSM La Roche Color Fan (Table 2). If compared to the treatment B, more intensive yolk color was determined in the experimental group BK (12.00 and 14.42, respectively). Egg yolk color intensity was significantly reduced as depending on cooking length. Group B with egg yolk color of 12.00 reduced color to 9.14 after 7 minutes of

cooking and to 7.28 after 10 minutes of cooking. The decreasing value for yolk color was also determined in the group BK (14.42 > 13.00 > 8.42, respectively). Fresh eggs exhibited no difference in yolk color, i.e. the L* values were similar (B=61.85 and BK=59.24).

Table 2. *Effect of treatment and cooking length and their interaction on yolk color*

Cooking length (CL; min)	Treatment (*T)	La Roche	Lightness (L*)	Redness (a*)	Yellowness (b*)
0	B	12.00^{c}	61.85^{cd}	9.78^{cb}	52.17^{b}
	BK	14.42^{a}	59.24^{ed}	8.98^{cb}	27.33^{d}
7	B	9.14^{de}	73.77^{b}	5.75^{de}	54.21^{b}
	BK	13.00^{b}	48.12^{f}	14.77^{a}	42.62^{c}
10	B	7.28^{f}	83.28^{a}	4.93^{e}	55.25^{b}
	BK	8.42^{de}	63.25^{c}	10.63^{b}	66.84^{a}
SEM		0.265	1.332	0.662	2.128
Probability	CL	<0.001	<0.001	<0.001	<0.001
	T	<0.001	<0.001	<0.001	<0.001
	CL*T	<0.001	<0.001	<0.001	<0.001

*B=standard laying hens' feed; BK=100 mg/kg vit. E+200 mg/kg lutein+0.5mg/kg Se+5% of oil mixture.
NS- non-significant. Values in columns marked by different exponents $^{a-f}$ differ statistically.

However, by cooking the B group eggs, the L* values statistically significantly increased (61.85<73.77<83.28), while L* values of yolk in the BK group varied (59.24>48.12<63.25). Similar research results were published by Englmaierova and Skrivan (2013). These authors reported that hen groups fed diets supplemented with lutein laid eggs, whose yolk cooked for 5 minutes, decreased the L* values in comparison with fresh yolk, while all the values in yolks cooked for 7 minutes were increased. Since yolks from treatment B increased the L* value along with length of cooking, a significant lowering of value a* (redness) occurred for 10 minutes of cooking eggs, while value b* (yellowness) was balanced. On the contrary, the length of cooking in BK treatment had statistically significant effect on the increase of a* and b* values. Similar results were obtained by Englmaierova and Skrivan (2013). Figure 1 shows values of lipid oxidation in fresh eggs and in eggs stored for 28 days at 4°C. It is concluded that values of TBARS in fresh eggs of both treatment were similar (B=0.735µg MDA/g and BK=0.745µg MDA/g). Slightly intensive lipid oxidation was observed in eggs of BK treatment that were stored for 28 days at 4°C if compared to eggs from treatment B (0.805µg MDA/g and B=0.778µg MDA/g, respectively). Such occurrence can be explained with the fact that treatment BK, unlike treatment B, was given feed supplemented with oil mixture (5%), which could cause slightly higher oxidation of egg yolk lipids. However, TBARS values that indicate lipid oxidation were not influenced by treatment, length of egg storage and their interaction (P>0.05).

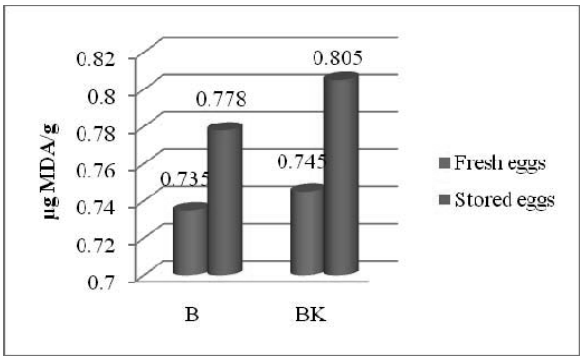

Figure 1. *Values of egg yolk lipid oxidation*

Conclusion

The paper elaborated effects of treatments (B=control group given diets of standard composition and BK=diets supplemented with 100 mg/kg vitamin E+200 mg/kg lutein+0.5mg/kg Se+5% oil mixture), cooking length (0, 7 and 10 minutes) and their interactive influence on yolk color and egg quality. Research results pointed out that supplementation of lutein, vitamin E, selenium and oil mixture had statistically significant influence on occurrence of more intensive color of fresh yolk, while cooked eggs had lighter color of yolks. The B group exhibited less intensive lowering of yolk color when depended on cooking length than the treatment BK. Intensity of yolk color increased when depending on cooking length (treatment B), and consequently the same yolks exhibited decrease of redness intensity (a*), while values for yellowness (b*) were similar. That was not the case in the treatment BK, where the intensity of yolk color (L*) varied. Value L* decreased in eggs cooked for 7 minutes, but in eggs cooked for 10 minutes it significantly increased if compared to fresh eggs. Depending on the cooking length, values a* and b* of BK yolks follow the trend of increase. The treatment, length of storage and their interaction had no effects on obtained results for egg yolk lipid oxidation.

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