EFFECT OF SUNFLOWER AND RAPESEED OIL, ORGANIC AND INORGANIC SELENIUM AND VITAMIN E IN THE DIET ON YOLK FATTY ACIDS PROFILE, MALONDIALDEHYDES CONCENTRATION AND SENSORY QUALITY OF LAYING HENS EGGS

Vilija Buckiuniene[1], Gitana Alencikiene[3], Aldona Miezeliene[3], Asta Raceviciute-Stupeliene[1], Saulius Bliznikas,[2] Romas Gruzauskas*

[1]Lithuanian University of Health Sciences, Veterinary Academy
Tilzes str. 18, LT-47181, Kaunas, Lithuania, tel/fax: +37037363505
[2]Lithuanian University of Health Sciences, Inst. of Animal Science
Baisogala, Radviliskis distr. Lithuania
[3]Food Institute of Kaunas University of Technology, Kaunas, Lithuania

[*]Corresponding author: vilija.buckiuniene@lsmuni.lt

Abstract. The aim of this study was to investigate the effects of diets with supplemented oils, selenium and vitamin E on the contents malondialdehydes (MDA) and fatty acids profile, texture properties and sensory quality of laying hens eggs. In total, 48 *Lohman Brown* laying hens 28 weeks old were assigned to four treatment groups (12 hens per each treatment group) and fed with one of the experimental diets for 8 weeks and keeping in the same conditions. The content of MDA in fresh raw eggs ranged from 0.204 to 0.232 μmol/kg sample, SFA concentration in egg yolk in experimental groups had tendency to decreased from 0.44 to 1.02 percent ($P<0.05$), MUFA – in experimental group I – decreased 1.31 percent ($P>0.05$), in experimental group II also decreased 0.93 percent ($P>0.05$), but PUFA increased in experimental group I – 0.35 percent ($P>0.05$), compared to the control group.

The results of present study showed that oil derived from sunflowers or rapeseed can be used with organic or inorganic selenium as supplements to the diet of laying hens without any significantly negative effect on eggs sensory and texture properties, acceptability. Compound feed supplemented with different oils and selenomethionine did improve omega 6 and omega 3 ratio respectively 9.18 and 1.41 point ($P<0.05$) compared with control group, but increased MDA level on storage and fresh eggs.

Keywords: Malondialdehydes, fatty acid, eggs, texture prfile

Introduction. Nowadays, consumers are gradually interested in foods that not just support nutritional needs, also concern health benefits (Kim et al., 2010). González-Esquerra and Leeson (2001) noted that omega-3 fatty acids have the possibility for reducing rates of various diseases, such as cardiovascular disease and diabetes. To reduce coronary heart disease, linoleic acid is the best replacement of saturated fatty acids. However, because of their high polyunsaturated fatty acids (PUFA) values, vegetable oils have the possibility to quickly reduce the product stabilities. Xiong and Jiang (2015) noted that providing oxidative stability with the use of vegetable oils with high PUFA values would be an important challenge to researchers. The contents of egg components maybe changed by the diet, and the inclusion of specific ingredients in layer feeds have been used to change the yolk lipid profile and to improve yolk quality. There is evidence that hens have a unique ability to deposit dietary lipid into the egg yolk, which makes the egg a potential source of polyunsaturated fatty acids (PUFAs). The inclusion of n-3 PUFA promotes a qualitative change in the yolk fatty acid profile and reducing the n-6/n-3 ratio to a more beneficial level concerning the human nutritional needs (Simopoulos, 2006).

Another important egg quality item is lipid stability, as the yolk fatty acids may suffer lipid oxidation during storage. Lipid oxidation affects food quality, particularly its aroma, taste, and nutritional value, in addition of producing toxic compounds. Fatty acids, particularly unsaturated fatty acids, are the compounds most susceptible to oxidation. Consequently, the inclusion of polyunsaturated fatty acids in layer diets may increase the susceptibility of eggs to lipid oxidation (Cherian et al., 2007). Antioxidants, such as tocopherol, may be added to layer diets to protect fatty acids from oxidation and to enrich eggs with vitamin E.

Selenium (Se) is an essential trace mineral that is important for growth as a component of poultry nutrition (Selle and Cowieson, 2013). Vitamin E plays an important role in various biochemical and physiological processes, including antioxidant activity (Litta et al., 2014).

Many studies have demonstrated opportunities to manipulate saturated (SFA) and unsaturated (UFA) fatty acids, since their composition and ratios depend partly on dietary intake (Polawska et al., 2013). Our modern diets are low in n-3 fatty acids, leading to an increased n-6:n-3 fatty acid ratio. In general, oxidation products are considered as inducers of cardiovascular and atherogenesis problems. Lipid oxidation contributes to undesirable changes in a number of products quality parameters, including loss of texture, flavor, water-holding capacity and etc. Vitamin E and Se are key components of the antioxidant system, reducing lipid peroxidation. Supplementation of vitamin E significantly improved the meat stability against oxidative deterioration. Vitamin E is the primary lipid-soluble antioxidant found in foods and human blood and tisuess. It

is well known that vitamin E inhibits the process of lipid peroxidation in oils and in the biological lipid-protein complexes such as biological membranes or circulating lipoproteins (Fellenberg and Speisky, 2006). Selenium plays an important role in the antioxidant defence system.

Thus, the aim of the trial was to investigate how organic forms of selenium and vitamin E with sunflower and rapseed oil in compound feed influence the sensory and texture properties of fresh and for 28 days stored eggs. Special attention was paid to the interaction between selenium, lipid oxidation and fatty acids profiles in the eggs.

Material and Methods

Scientific research were carried out in accordance with the new version of the 2013-01-01 1997-11-06 Republic of Lithuania, animal care, storage and use of the law (Republic of Lithuania, animal welfare and protection of the law), (Valstybės žinios, 2012, Nr. 122-6126) and an executive act - Lithuania Minister of State Food and Veterinary "Service of the order on animals used for experimental and other scientific research, storage, maintenance and operation of approval (Valstybės žinios, 2009-01-22, Nr.8-287). It is also according with 2010 of 22 September, European Parliament and Council Directive 2010/63 / EU and EC recommendations 2007/526 EC Animal Use and storage for experimental and other purposes.

A feeding trial was conducted on 48 *Lohman Brown* laying hens, aged 28 weeks. The birds were divided into 4 groups, 12 hens in each group and fed with the experimental diets for 8 weeks: group I (control) – sunflower oil+0.5 mg Na_2SeO_3 (analysed 0.38 mg/kg)+40 mg/kg (analysed 38 mg/kg) vit. E, group II (control) – rapeseed oil+0.5 mg (analysed 0.45 mg/kg) Na_2SeO_3 + 40 mg/kg (analysed 35 mg/kg) vit. E, group I (experimental) – sunflower oil + 0.5 mg (0.44 mg/kg) selenomethionine + 40 mg/kg (analysed 33 mg/kg) vit. E, group II (experimental) – rapeseed oil + 0.5 mg (analysed 0.44 mg/kg) selenomethionine + 40 mg/kg (analysed 36 mg/kg) vit. E. All hens were kept under the same conditions. All diets were formulated to meet or exceed the nutritional requirements of birds as suggested by NRC (1994) with the exception of Se concentration (Table 1). The hens were fed with 125 g compound feed per day.

The quality parameter of compound feed – humidity, crude protein, crude fat, crude ash, total phosphorus, calcium, natrium – were estimate by the near infrared reflectance spectroscopy (NIRS).

Characteristics of in experiment used feed additives

Alkosel®R397 (selenomethionine) – is inactive yeast (Saccharomyces cerevisiae NCYC R397) product, an essential trace element of selenium source, which is easily assimilated natural organic form of selenium – L (+) selenomethionine. L (+) selenomethionine yeast by cultivation in a medium containing the prescribed amount of selenium. Live yeast cells absorbs selenium and converts it to L (+) selenomethionine and other selenium-containing proteins. The total amount of Se 2000-2400 ppm.

Table 1. **Composition and nutrient content of the compound feed**

Components	**Composition**
Wheat	60.38
Soybean meal	12.89
Wheat flour	10.46
Limestone	8.22
Sunflower meal	6.00
Monocalcium phosphate	0.98
Premix for laying hens *HENS*	0.50
NaCl	0.21
DL-Metionine	0.16
Organic acid mix	0.10
Natrium sulphate	0.06
L-Lysine Sulphate	0.04
Quality parameters of compound feed, 1kg	
Metabolic energy MJ/kg	11.40
Protein*	17.07
Crude fat*	3.12
Crude fiber*	3.28
Crude ash*	11.95
Ca*	3.45
P (total)*	0.67
P	0.42
Na	0.13
Mg	0.12
K	0.72
Cl	0.17
NaCl	0.22
Lysine	0.71
Methionine	0.39
Methionine+cistinas	0.70
Triptophan	0.22
Treonine	0.55
*-analysed value. Composition of premix: Ca – 3.45%, P – 0.67%, Na – 0.13%., lysine – 0.71%, metionine – 0.39%, metionine+cistine – 0.70%, triptophane –0.22%, treonine – 0.55%, vit. E – 40.00 mg/kg, vit. A – 11.000 TV, vit. D3 – 2.500 TV, vit. K3 – 2.50 mg/kg, vit. B1 – 2.50 mg/kg, vit. B2 –7.00 mg/kg, vit. B6 – 4.00 mg/kg, vit. B12 – 25 µg/kg, nicotinic acid – 55.00 mg/kg, pantothenic acid – 15.00 mg/kg, folic acid –1.75 mg/kg, biotin –100.00 µg/kg, choline chloride – 399.00 mg/kg, Fe – 70.00 mg/kg, Mn – 100.00 mg/kg, Zn – 60.00 mg/kg, Cu –6.00 mg/kg, I – 0.50 mg/kg, Se – 0.20 mg/kg, Co – 0.10 mg/kg.	

Sodium selenite – the active substance contains has 45 percent, trace of heavy metals. White powder, in contact with skin – burns, soluble in water, the solubility of 46.3 per cent, melting temperature of 710°C, the heat of vaporization – 26.32 kJ/mol, covalent radius – 116 pm.

Vitamin E – Microvit® E Promix 50. Vitamin E levels – at least 500 IU/g (50 per cent) The chemical formula – C31H52O3, cream-colored powder, particle size – less than 500 micrometre from 0.5 per cent. up to 5 per cent. more than 160 µm – 5 per cent. 15 per cent, water-insoluble.

Determination of the selenium and vitamin E content

Content of Se in the compound feed were determined by AA spectrometry (Thermo SCIENTIFIC ice 3000 series, Thermo Fisher Scientific, UK). Mineralization was determined with Mars Xpress (CEM Corporation, USA).

Vitamin E concentration were determined in accordance with the EN 12822 (2000) by HPLC (Shimadzu, Varian ProStar).

Determination of fatty acids profiles

Extraction of lipids for fatty acid analysis was performed with chloroform/methanol (2:1 v/v) as described by Folch et al. (1957). Fatty acid methyl esters (FAME) were prepared using the procedure of Christopherson and Glass (1969). The samples were analyzed according to current standards – ISO 5555:2001 Animal and vegetable fats and oils. The sampling was prepared in accordance with ISO 661:2003 Animal and vegetable fats and oils. Qualitative analysis of fatty acids was done. A more detailed description of the method is provided by Buckiuniene et al. (2016a).

Determination of lipid oxidation

The malondialdehyde content in egg yolk was determined by high performance liquid chromatography as described by Mendes et al. (2009). A more detailed description of the method is provided by Buckiuniene et al. (2016b).

Sensory analysis

A sensory panel for the descriptive analysis consisted of 6 assessors experienced in sensory evaluation of different food products. The assessors were selected and trained according to ISO 8586:2012. A more detailed description of the method is provided by Buckiuniene et al. (2016a).

Measurement of texture properties

For preparation of the egg sample the modified (Woodward and Cotterrill, 1987) method was applied taking into account the remarks of adjusted to the present conditions. A more detailed description of the method is provided by Buckiuniene et al. (2016a).

Statistical Analysis

The results of the experiment were analyzed using the 1-way ANOVA test, and significant differences between groups were determined by Duncan's multiple range test. Statistica 8.0. for Windows™ software was used. Differences were considered significant at $P<0.05$.

Results and discussions

The fatty acid composition of egg lipids in laying hens can be influenced by the fatty acid composition of their diet (Beynen, 2004). The eggs from hens provided with standard feed are poor in linolenic acid (LNA; C18:3n-3), and does not contain eicosapentaenoic (EPA; C20:5n-3) and docosahexaenoic (DHA; C22:6n-3) fatty acids (Souza et al., 2008) . The majority of the egg's fatty acids are monounsaturated (~44%) with saturated and polyunsaturated accounting for ~29 and 11%, respectively (Filardi et al., 2005). There is evidence that hens have a unique ability to deposit dietary lipid into the egg yolk, which makes the egg a potential source of polyunsaturated fatty acids (PUFAs) (Simopoulos, 2006).

The inclusion of n-3 PUFA promotes a qualitative change in the yolk fatty acid profile and reducing the n-6/n-3 ratio to a more beneficial level concerning the human nutritional needs (Simopoulos, 2006; Agboola et. al., 2016).

Our results are in agreement with Kralik and Kralik (2017) which reported that PUFA concentration in the eggs yolk were better when compound feed was supplemented with rapeseed oil and Na2SeO3. The total percentage compositions of saturated, monounsaturated and polyunsaturated fatty acids in the egg yolks of the different treatments varied depending from vegetable oil and selenium source (Table 2). SFA concentration in egg yolk in experimental groups had tendency to decreased from 0.44 to 1.02 percent ($P<0.05$), MUFA – in experimental group I – decreased 1.31 percent ($P>0.05$), in experimental group II also decreased 0.93 percent ($P>0.05$), but PUFA increased in experimental group I – 0.35 percent ($P>0.05$), compared to the control group. Gül et al. (2012) pointed out that dietary supplementation of laying hens' feed with rapeseed oil resulted in increased MUFA, especially of oleic acid, in eggs. When compound feed was supplemented with rapeseed oil and Alkosel (experimental group II), omega 3 fatty acid increased 0.2 percent ($P<0.05$), omega 6 and omega 3 ratio had tendency to decreased from from 0.89 to 3.19 point ($P<0.05$) compared to the control group.

Lipid oxidation occurs during storage, especially at elevated temperatures (Mohiti-Asli et al., 2008), and is more pronounced in n-3 PUFA enriched eggs, due mainly to the presence of the unsaturated bonds (Hayat et al., 2010; Ren et al., 2013). The content of MDA in fresh raw eggs ranged from 0.204 to 0.232 μmol/kg sample (Table 3), but in experimental group II this parameter increased 11 percent ($P<0.05$).

The results are dissagree with Nimalaratne et al. (2016) and the results published by Mohiti-Asli et al. (2008) who did not observe changes in MDA content in eggs stored at 4 °C for two weeks but found an increase at room temperature.

The inclusion of sunflower oil to laying hen diet has some effect on eggs quality parameters such as eggs off-flavour (Alvarez et al., 2005). Contraversely to these data, no significant effect of sunflower oil was found on yolk colour and Haugh unit (Tsuzuki et al., 2003), egg mas and weight (Arúajo et al., 2015), or sensory properties.

Our results did not prove this statement as there was no effect of oil source on eggs yolk or albumen hardness, cohesiveness, springiness or chewiness (Table 4). Springiness of fresh eggs albumens was the only texture property affected by oil source. Sunflowers oil in feed resulted by lower fresh eggs albumens springiness in comparision with rapeseed ($P<0.05$). Effect of selenium source was significant on fresh egg albumen hardness and chewiness, but not affected other texture properties. When laying hens feed was supplemented with inorganic selenium, freh eggs albumens were more soft and chewiness lower in comparision with one with organic selenium ($P<0.01$). No significant interactions between oil source × selenium source with respect to fresh eggs texture were determined (Table 4).

Table 2. **Effect of oil and selenium source on fatty acid concentration in the egg yolk, %**

Fatty acid	Groups			
	I control (sunflower oil + 0.5 mg Na2SeO3 + 40 mg vit. E/kg)	**II control (rapeseed oil + 0.5 mg Na2SeO3 + 40 mg vit. E/kg)**	**I experimental (sunflower oil + Alkosel®R397 0.5 mg + vit. E 40 mg/kg)**	**II experimental (rapeseed oil +0.5 mg Alkosel®R397 + vit. E 40 mg/kg)**
C14:0	0.21±0.02	0.21±0.03	0.21±0.03	0.21±0.03
C15:0	0.10±0.01	0.10±0.01	0.10±0.01	0.11±0.01
C16:0	22.13±0.30	22.01±0.49	22.72±0.44	22.86±1.01
C16:1 n-9	0.83±0.15	1.17±0.07	0.85±0.17	1.04±0.12*
C16:1 n-7	1.52±0.15	1.67±0.26	1.30±0.11	1.66±0.17*
C17:0	0.19±0.02	0.19±0.02	0.22±0.01	0.21±0.02
C18:0	8.46±0.25	7.56±0.46	8.47±0.66	7.26±0.05*
C18:1 n-9	38.65±1.60	44.85±0.98	38.49±1.39	44.27±1.40
C18:1 n-7	1.79±0.06	1.79±0.18	1.25±0.10	1.58±0.30
C18:2 n-6	22.97±0.97	17.39±0.74	22.35±1.22*	17.08±0.32*
C22:4 n-6	0.18±0.04	0.14±0.02	0.16±0.03	0.13±0.02
C22:6 n-3	0.82±0.10	1.00±0.13	0.81±0..17*	1.20±0.08*
SFA	31.09±0.42	30.07±0.14	31.72±0.85	30.65±1.07*
MUFA	42.79±1.71	49.48±0.89	41.48±1.59	48.55±1.26*
PUFA	23.97±1.47	18.53±0.90	24.32±1.41	18.41±0.37*
Trans-isomers	0.16±0.03	0.16±0.01	0.18±0.02	0.17±0.01
PUFA/SFA	0.77±0.04	0.62±0.03	0.77±0.05	0.60±0.03
n-6	23.15±1.43	17.53±0.76	22.15±1.36	17.21±0.36*
n-3	0.82±0.15	1.00±0.20	0.81±0.77	1.20±0.03*
(n-6)/(n-3)	28.23±4.32	17.53±0.76	27.34±5.20*	14.34±0.26*
IA	0.4±0.01	0.31±0.01	0.33±0.01	0.31±0.02
IT	0.84±0.02	0.71±0.01	0.79±0.02	0.67±0.04
h/H	2.93±0.06	3.17±0.09	3.02±0.09	3.22±0.21
IP	37.60±1.96	36.00±1.50	490±2.84	39.40±0.83
Not identified FA	2.15	1.92	0.92	2.39
*- data statistically significant at P<0.05				

Table 3. **Effect of dietary treatment on MDA concentration in the egg yolk, µmol/kg**

Parameter	Groups			
	I control (sunflower oil + 0.5 mg Na2SeO3 + 40 mg vit. E/kg)	**II control (rapeseed oil + 0.5 mg Na2SeO3 + 40 mg vit. E/kg)**	**I experimental (sunflower oil + Alkosel®R397 0.5 mg + vit. E 40 mg/kg)**	**II experimental (rapeseed oil +0.5 mg Alkosel®R397 + vit. E 40 mg/kg)**
Fresh egg yolk	0.216±0.021	0.204±0.009	0.232±0.018	0.226±0.019*
Storage after 30 days egg yolk	0.300±0.020	0.322±0.033	0.406±0.076*	0.398±0.050*
*- data differ signifficant at P<0.05				

Analysis of TPA (texture profile analysis) results of eggs stored for 30 days revealed that there was a significant interaction between oil source and selenium source with respect to albumens hardness, springiness and chewiness (Table 4). When sunflower oil was used the albumens hardness and chewiness was higher for organic selenium group, but springiness was not affected. For rapeseed oil only cohesiveness was affected by selenium source, and cohesiveness was lower when inorganic selenium was used.. Sensory analysis of fresh eggs showed that intensity of overall odour or taste, color homogenicity was not affected by feed composition (Table 5). The only property affected by feed type was hardness of albumen and yolk. Origin of selenium had no effect on albumen hardness in case of sunflower oil, but when rapseed oil was used albumen yolk was more hard when organic selenium was replaced by inorganic.

After 30 days storage sensory properties of eggs albumens color or texture were similar and not depended from hens feed composition. But some non typical for hard boiled egg albumen taste and odor (as described by Parapinello et al., 2006) was determined and decreased acceptability of eggs when rapeseed oil with organic selenium was used in feed. When sunflower oil was used non typical odor of albumen was less intensive in case of organic selenium addition. As this non typical odor was o nly just noticeable albumen was rated as acceptable (Table 5).

Table 4. **Effect of oil and selenium source on texture characteristics of fresh and 30 days stored eggs**

Texture characteristic	**I control (sunflower oil + 0.5 mg Na2SeO3 + 40 mg vit. E/kg)**	**II control (rapeseed oil + 0.5 mg Na2SeO3 + 40 mg vit. E/kg)**	**I experimental (sunflower oil + Alkosel®R397 0.5 mg + vit. E 40 mg/kg)**	**II experimental (rapeseed oil +0.5 mg Alkosel®R397 + vit. E 40 mg/kg)**	Oil	Se	Oil×Se
Fresh eggs							
Albumen							
Hardness, N	9.01	12.46	13.66	13.4	ns	0.001	ns
Cohesiveness	0.558	0.53	0.486	0.51	ns	ns	ns
Springiness, mm	7.65	8.05	7.47	7.97	0.024	ns	ns
Chewiness	48.48	53.21	51.96	54.42	ns	0.006	ns
Yolk							
Hardness, N	18.7	14.47	14.42	15.86	ns	ns	ns
Cohesiveness	0.552	0.464	0.465	0.419	ns	ns	ns
Springiness, mm	6.29	5.94	6.02	5.1	ns	ns	ns
Chewiness	64.83	42.63	40.55	35.31	ns	ns	ns
Eggs after 30 days storage							
Albumen							
Hardness, N	11.42	13.09	15.34	12.08	ns	ns	0.011
Cohesiveness	0.51	0.456	0.589	0.566	ns	ns	ns
Springiness, mm	8.19	7.87	7.84	8.22	ns	ns	0.036
Chewiness	47.81	47.99	70.83	56.21	ns	ns	0.005
Yolk							
Hardness, N	11.99	8.55	8.81	10.53	ns	ns	ns
Cohesiveness	0.287	0.259	0.328	0.325	ns	ns	ns
Springiness, mm	4.63	3.82	4.58	4.73	ns	ns	ns
Chewiness	16.46	8.49	17.73	16.85	ns	ns	ns
ns - not significant (P > 0.05)							

Table 5. **Effect of oil and selenium source on intensity of sensory properties of fresh and 30 days stored eggs**

Texture characteristic	**I control (sunflower oil + 0.5 mg Na2SeO3 + 40 mg vit. E/kg)**	**II control (rapeseed oil + 0.5 mg Na2SeO3 + 40 mg vit. E/kg)**	**I experimental (sunflower oil + Alkosel®R397 0.5 mg + vit. E 40 mg/kg)**	**II experimental (rapeseed oil +0.5 mg Alkosel®R397 + vit. E 40 mg/kg)**	Oil	Se	Oil×Se
Fresh eggs							
Albumen							
Overall odor	7.9	7.9	7.8	8.3	ns	ns	ns
Non typical odor	1.2	1.0	1.1	1.3	ns	ns	ns
Color homogeneity	7.8	7.8	7.1	7.3	ns	ns	ns
Hardness	4.3	4.8	4.3	4.3	ns	ns	0.023
Overall taste	7.2	7.3	6.5	7.3	ns	ns	ns
Non typical taste	1.1	1.0	1.0	1.2	ns	ns	ns
Acceptability	7.9	7.8	7.3	7.8	ns	ns	ns
Yolk							
Overall odor	7.1	7.3	7.3	7.2	ns	ns	ns
Non typical odor	1.0	1.0	1.0	1.0	ns	ns	ns
Color intensity	3.0	3.2	3.2	3.2	ns	ns	ns
Hardness	3.6	3.8	3.6	4.1	ns	ns	0.012
Granularity	2.5	2.6	2.8	2.5	ns	ns	ns
Overall taste	7.5	7.6	7.6	7.7	ns	ns	ns

Non typical taste	1.0	1.2	1.5	1.5	ns	ns	ns
Aftertaste	4.8	4.9	5.0	4.8	ns	ns	ns
Acceptability	7.9	7.8	7.3	7.5	ns	ns	ns
Stored for 30 days eggs							
Albumen							
Overall odor	7.9	7.6	7.7	7.8	ns	ns	ns
Non typical odor	2.3	2.3	1.8	2.3	ns	ns	0.034
Color homogeneity	7.0	7.1	6.5	7.0	ns	ns	ns
Hardness	5.4	5.0	5.7	5.3	ns	ns	ns
Overall taste	6.7	6.7	6.7	6.8	ns	ns	ns
Non typical taste	1.3	2.0	1.3	1.8	ns	ns	0.026
Acceptability	7.1	6.8	7.1	6.7	ns	ns	0.043
Yolk							
Overall odor	7.0	6.9	6.9	6.8	ns	ns	ns
Non typical odor	1.3	1.8	1.3	1.6	0.004	ns	0.038
Color intensity	2.9	2.7	3.0	2.8	0.001	0.007	0.007
Hardness	3.1	3.2	3.3	3.8	ns	0.002	0.000
Granularity	2.3	2.2	2.1	2.1	ns	ns	ns
Overall taste	7.0	6.8	6.8	7.2	ns	ns	ns
Non typical taste	1.5	2.0	1.8	2.0	ns	ns	n.s
Aftertaste	4.9	4.8	4.7	4.7	ns	ns	ns
Acceptability	7.0	6.4	6.7	6.6	ns	ns	ns
ns - not significant (P > 0.05)							

Some studies (Ahn et al., 1999) revealed that changed composition of eggs fatty acids may have negative effect (more rubberry and hard yolk) on yolk texture parameters, especially during refrigerated storage. In the present study, eggs yolk texture properties were not affected by dietary treatment , thus data are in agreement with results presented by other authors (Ahn et al., 1999).

Several studies suggested that incorporation of linseed or rapeseed into laying hens feed negativelly affected sensory properties of eggs (Jiang et al., 1992) as unpleasant flavour were detected. About 30% of consumers were able to perceive non typical flavour, which was described as „fishy" in case when flaxseed were added to feed. Such non typical flavour was the reason why consumers acceptance of eggs was lower. Possible negative effect of polyunsaturated oils in hens diet on sensory quality of eggs could be avoided or minimised by changing: oil source (rapeseed or flaxseed, whole versus ground flaxseed), amount of added oil, by using antioxidants (Tseveni-Cousi et al., 2001).

Colour homogeneity of albumens was not affected by oil source, thus our data are not in agreement with some studies (Ceylan et al., 2011), which determined that higher amount sunflower oil added to laying hens feed resulted in visible spots in eggs albumen and yolk. Yolk properties also were affected by oil source. Samples with rapeseed oil had more intensive non typical odour than samples with sunflower oil. But intensity of this off-odour was described only as just noticeable, but panellists were not able to describe it character, as it concentration was lower that threshold of recognition.

Conclusions

Compound feed supplemented with different oils and selenomethionine did improve omega 6 and omega 3 ratio respectively 9.18 and 1.41 point (P<0.05) compared with control group, but increased MDA level on storage and fresh eggs.

Results of our study demonstrated that different oils, selenomethionine and vitamin E had varying effects on eggs properties, of fresh eggs decreased chewiness and springness of albumen. After storage 30 days, hardness and cohesiveness of eggs yolk and albumen.

Acknowledgements

This research was supported by the grant of the Ministry of Agriculture Of the Republic of Lithuania (No. MT/11-30 LESPRO). National Research Programme Healthy and Safe Food.

References

1. Agboola A. F., Omidiwura B. R. O., Oyeyemi A., Iyayi A. E., Adelani A. S. Effects of four dietary oils on cholesterol and fatty acid composition of egg yolk in layers. International Schollar and Science Research & Innovation. 2016. 10 (2). P. 32-40.

2. Ahn D. U., Sell J. L., Chamruspollert C. J. M., Jeffrey M. Effect of Dietary Conjugated Linoleic Acid on the Quality Characteristics of Chicken Eggs During Refrigerated Storage. Poultry Science. 1999. 78. P. 922–928.

3. Alvarez C., García-Rebollar P., Cachaldora P., Méndez J., De Blas J.C. Effects of dietary conjugated linoleic acid and high-oleic sunflower oil on performance and egg quality in laying hens. British Poultry Science. 2005. 46 (1). P. 80–86.

4. Araújo W. A. G., Albino L. F. T., Rostagno H. S.,

Pessoa G. B. S., Cruz S. C. S., Lelis G. R., Carneiro P. R. O., Vieira R. A. Sunflower Meal and Supplementation of an Enzyme Complex in Layer Diets. Revista Brasileira de Ciência Avícola. 2015. 17 (3). P. 363–370.

5. Beynen A. C. Fatty acid composition of eggs produced by hens fed diets containing groundnut, soybean or linseed. Journal of Animal Science. 2004. 52. P. 3-10.

6. Buckiuniene V., Grashorn M. A., Gruzauskas R., Kliseviciute V., Raceviciute-Stupeliene A., Svirmickas G., Bliznikas S., Miezeliene A. and Alencikiene G. Effect of organic and inorganic iron in the diet on yolk iron content, fatty acids profile, malondialdehyde concentration, and sensory quality of chicken eggs. European Poultry Science. 2016a. 80. P. 1-13.

7. Buckiuniene V., Gruzauskas R., Kliseviciute V., Raceviciute-Stupeliene A., Svirmickas G., Bliznikas S., Miezeliene A. and Alencikiene G., Grashorn M. A. Effect of organic and inorganic iron on iron content, fatty acid profile, content of malondialdehyde, texture and sensory properties of broiler meat. European Poultry Science. 2016b. 80. P. 1-13.

8. Ceylan N., Ciftci I., Mizrak C., Kahraman Z., Efil H. Influence of different dietary oil sources on performance and fatty acid profile of egg yolk in laying hens. Journal of animal and feed sciences. 2011. 20 (1). P. 71–83.

9. Cherian G., Traber M. G., Goeger M. P., Leonard S. W. Conjugated linoleic acid and fish oil in laying hen diets: effects on egg fatty acids, thiobarbituric acid reactive substances, and tocopherols during storage. Poultry Science. 2007. 86 (5). P. 953–958.

10. Christopherson S. W., Glass R. L. Preparation of milk fat methylester by alcoholysis in an essentially non-alcoholic solution. Journal of Dairy Science. 1969. 52. P. 1289–1290.

11. Fellenberg M. A., Speisky H. Antioxidants: their effect on broiler oxidative stress and its meat oxidative stability. World Poultry Science Journal. 2006. 62. P. 53–70.

12. Filardi R. S., Junqueira O. M., De Laurentiz A. C., Casartelli E. M., Rodriques E. A., Araujo L. F. Influence of different fat sources on the performance, egg quality, and lipid profile of egg yolks of commercial layers in the second laying cycle. Journal Applied Poultry Research. 2005. 14. P. 258-264.

13. Folch J., Less M., Sloane-Stanley G. H. A simple method for isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry. 1957. 226. P. 497–509.

14. González-Esquerra R., Leeson S. Alternatives for enrichment of eggs and chicken meat with omega-3 fatty acids. Canadian Journal of Animal Science. 2001. 81. P. 295–305.

15. Gül M., Yoruk M. A., Aksu T., Kaya A., Kaynar O. The effect of different levels of canola oil on performance, egg shell quality and fatty acid composition of laying hens. International Journal of Poultry Science. 2012. 11. P. 769-776

16. ISO 8586:2012. Sensory analysis–General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors. P. 1-31.

17. ISO 5555:2001. Animal and vegetable fats and oils Sampling. P. 3-12.

18. ISO 661:2003. Animal and vegetable fats and oils - Preparation of test sample. P. 1-15.

19. Kim H. Y., Lee E. S., Jeong J. Y., Choi J. H., Choi Y. S., Han D. J., Lee M. A., Kim S. Y., Kim C. J. Effect of bamboo salt on the physicochemical properties of meat emulsion systems. Meat Science. 2010. 86. P. 960–965.

20. Kralik G. and Kralik Z. Poultry products enriched with nutricines have beneficial effects on human health. Medicinski Glasnik. 2017. 14(1). P. 1-7.

21. Litta G., Chung T. K., Weber G. M. Vitamin E: vital for health and performance. Word Poultry Science. 2014. 8. P. 19–21.

22. Mendes R., Cardoso C., Pestane C. Measurement of malondialdehyde in fish: A comparison study between HPLC methods and the traditional spectrophotometric test. Food Chemistry. 2009. 112. P. 1038–1045.

23. Mohiti-Asli M., Shariatmadari F., Lotfollahian H., Mazuji M. T. Effects of supplementing layer hen diets with selenium and vitamin E on egg quality, lipid oxidation and fatty acid composition during storage. Canadian Journal of Animal Science. 2008. 88 (3). P. 475–483.

24. Nimalaratne C., Schieber A., Wu J. Effects of storage and cooking on the antioxidant capacity of laying hen eggs. Journal of Food Chemistry. 2016. 194. P. 111–116.

25. NRC. National Research Council. Nutrient requirements of poultry. 9th ed. National Academy Press Washington, D.C., USA. 1994.

26. Parpinello G. P., Meluzzi A., Sirri F., Tallarico N., Versari A. Sensory evaluation of egg products and eggs laid from hens fed diets with different fatty acid composition and supplemented with antioxidants. Food Research International. 2006. 39. P. 47–52.

27. Polawska E., Hobranczuk J., Pierchala M., Strzalzawkowska N., Jozwik A., Wojcik A. Hoffman L. C. Effect of dietary linseed and rapeseed supplementation on the fatty acid profiles in the ostrich. Part 1. Muscles Animal Science. 2013. 31. P. 239–248.

28. Ren Y., Perez T. I., Zuidhof M. J., Renema R. A., Wu J. Oxidative stability of omega-3 polyunsaturated fatty acids enriched eggs. Journal of Agriculture and Food Chemistry. 2013. 61 (47). P. 11595–11602.

29. Selle P. H., Celi P., Cowieson A. Effects of organic selenium supplementation on growth performance, nutrient utilisation and selenium tissue concentrations in

broiler chickens. Proceedings of the 24th Australian Poultry Science Symposium (APSS). Veterinary Science Conference Centre; Fev 17-20; Sydney, AU. Sydney: University of Sydney. 2013. P. 58-63.

30. Simopoulos A. Evolutionary aspects of diet, the omega-6/omega-3 ratio and genetic variation: nutritional implications for chronic diseases. Biomedicine Pharmacy 2006. 60. P. 502–507.

31. Souza J. G., Costa F. G. P., Queiroga R. C. R. E., Silva S. H. V., Schwler A. R. P., and Goulart C. C. Fatty acid profile of eggs of semi-heavy layers fed feeds containing linseed oil. Brazilian Journal Poultry Science. 2008. 10. P. 37-44.

32. Tseveni-Cousi E. T., Garcia E. R., Murakami A. E., Sakamoto M. I., Galli J. R. Utilization of Sunflower Seed in Laying Hen Rations. British Journal of Poultry Science. 2001. 5 (3). P. 179–182.

33. Tsuzuki, E. T., Garcia E. R. Murakami M., Sakamoto A. E., Galli J. R. Utilization of sunflower seed in laying hen rations. Revista Brasileira de Ciência Avícola. 2003. 5(3). P. 179–182.

34. Woodward S. A., Cotterrill O. J. Texture and Microstructure of cooked whole egg yolks and heat – formed gels of stirred egg yolk. Journal of Food Science. 1987. 52. P. 63–67.

35. Xiong Y. L., Jiang J. Role of interfacial protein membrane in oxidative stability of vegetable oil substitution emulsions applicable to nutritionally modified sausage. Meat Science. 2015. 109. P. 56–65.

Received 15 May 2018
Accepted 29 May 2018