

The effect of essential oils on quality and mineral composition of eggshells

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The aim of study was to analyse the dietary effect of pumpkin and flaxseed oils on quality and mineral composition of laying hens eggshell. At 38 weeks of age, Lohmann Brown Lite hens were housed in three-floor cages, divided into three dietary groups (C-control, E1-pumpkin oil (3%), E2-flaxseed oil (3%)). There were housed six hens in one cage. A total 18 hens were monitored. In the control group hens were fed with standard complete feed mixture for laying hens and in the experimental groups by feed mixtures with supplementation of pumpkin or flaxseed oils. Vitamin E was added into feed mixture in the experimental groups. The experiment lasted 52 days. Twelve eggs from each dietary treatment were randomly selected and analyzed. Significant ($P < 0.05$) differences between control and both experimental groups in eggshell strength and eggshell thickness were found. Pumpkin and flaxseed oil supplementations in feed ratio of layers had positive impact on quality of eggshell. As regards the mineral composition of eggshell, significantly ($P < 0.05$) lower contents of magnesium, sodium, potassium and copper in experimental groups compared to the control were observed in eggshell. Significant ($P < 0.05$) differences in content of calcium were detected only between E1 (pumpkin addition) and E2 (flaxseed addition).

Keywords: eggshell, feed mixture, flaxseed oil, minerals, pumpkin oil

1 Introduction

Eggs are made up of a variety of chemical components, including water, protein, fatty acids, minerals, vitamins, and pigments (Li-Chan and Kim, 2008). Eggs are very good source of vitamins A, D, E and K and whole complex of vitamins of group B also comprising B₁₂ which are necessary for well-functioning nervous system. Also includes folic acid, iron, phosphorus, sulphur, potassium, magnesium and from trace elements it is zinc, copper, manganese, bromine and iodine (Nagy et al., 2009). In recent years global consumers are concerned about the livestock and poultry product due to the addition of additives into the feedstuff (European Commission, 2007). Vegetable oils, also called essential oils are aromatic, oily liquids obtained from plant material (flowers, buds, seeds, leaves, twigs, bark, herbs, wood, fruits and roots). It is a complex mixture of different organic molecules – terpenes, alcohols, esters, aldehydes, ketones and phenols. In animals, in particular, promote the secretion of gastric juices, while operating on gut motility and improve the integrity of the intestinal lining (Panda et al., 2009). Pumpkin seeds contain L-tryptophan, n-6 and n-3 fatty acids and very high concentration of

vitamin E (Hashemi, 2013). Pumpkin seeds also contain zinc and pumpkin peanuts to 54% oil with digestibility coefficient of 98.2% (Kóňa et al., 2007). Pumpkin seed oil has become a recognized source of phenolic compounds (Andjelkovic et al., 2010). Pumpkin oil has strong antioxidant properties (Stevenson et al., 2007). Flax seed contains about 40% oil, which can be used as part of feed mixture for poultry (Zelenka et al., 2008). Flaxseed oil contains high levels of polyunsaturated fatty acids and these compounds have been reported to reduce the incidence of heart disease and cancer in humans (Zhao et al., 2007). The main goal of this work was to determine the effect of essential oils on qualitative parameters and mineral composition of eggshell.

2 Material and methods

The experiment was carried out in accredited testing station of the Department of Poultry Science and Small Animal Husbandry (Faculty of Agrobiolgy and Food Resources, Slovak University of Agriculture in Nitra). At 38 weeks of age, Lohmann Brown Lite hens were housed in three-floor cages, divided into three diets of groups (C – control, E1 – pumpkin oil, E2 – flaxseed oil). There were

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Table 1 Nutrient composition of feed mixtures

Feed mixture components	C	E1	E2
Dry matter (%)	91.12	90.88	91.4
Crude protein (% of DM)	17.68	17.81	17.45
Crude Fat (% of DM)	6.53	7.61	7.59
Crude Fibre (% of DM)	4.09	3.71	3.78
Ash (% of DM)	12.01	11.49	11.26
NFE (% of DM)	50.81	50.26	51.32
Organic matter (% of DM)	79.11	79.39	80.14
Starch (% of DM)	35.3	35.62	35.45
Sugar (% of DM)	3.9	3.84	3.94
Ca (mg kg ⁻¹ DM)	41,468	38,567	39,059
P (mg kg ⁻¹ DM)	8,855	8,436	8,060

NFE – nitrogen-free extract, DM – dry matter, C – control group, E1 – pumpkin oil addition, E2 – flaxseed oil addition

six hens in one cage housed. The useful area provided for one laying hen presented 943.2 cm². Total 18 hens were monitored. The laying hens were kept in the standard bioclimatic and welfare conditions. During experiment, the light regime was 16 hours. The experiment lasted 52 days. In the control group (C), hens were fed with standard complete feed mixture for laying hens, in the experimental groups by feed mixtures supplemented with pumpkin (E1) or flaxseed (E2) oils. Concentration of oils was 3%. Laying hens in all groups received drinking water and feed mixture *ad libitum*. Nutrient composition of feed mixtures is presented in Table 1. At the last week the eggs were collected and processed. Shell thickness was measured at five locations on the egg (sharp, blunt and 3 equator end) using electronic micrometer Digitale Schiebelehre (Mister Tool). Strength of shell was determined using shell strength device with a spiral pressure system. Mineral composition of eggshell was determined by standard laboratory methods and procedures (AOAC, 2000). Content of ash was determined by complete combustion of the sample in a muffle furnace at 550 °C ±25 °C (4–6 hours) to oxidize all organic matter. The contents of mineral nutrients were determined by High Resolution Continuum Source Atomic Absorption Spectrometer ANALYTIK JENA contrAA 700 (Ca, Mg, Na, K, Zn, Cu, Fe, Mn) and 6400 Spectrophotometer (P). Laboratory analyses of minerals were carried out in the Laboratory of Quality and Nutritional Value of Feeds at the Department of Animal Nutrition in Slovak University of Agriculture. Statistical analysis was evaluated by using the statistical programme IBM SPSS 20.0.

3 Results and discussion

Eggshell strength is one of the most important external quality parameters of an egg, usually dependent on

egg shell proportion and thickness. Differences in egg shell physical parameters are dependent, among other factors, on the rate and extent of mineral deposition in the egg shell (Tůmová et al., 2014). Eggshell strengths of bursting and eggshell thickness are expressed in Table 2. Significant ($P < 0.05$) differences between control and both experimental groups in strength and thickness of shell were found. Average values of shell strength ranged from 21.76 N cm⁻² in control to 36.44 N cm⁻² in E1 (pumpkin oil addition). Arpášová et al. (2015) indicated eggshell strength 28.41 N cm⁻² after adding of oregano oil in diet. After oils supplementation, average eggshell thickness was same in both experimental groups (0.36 mm). Pumpkin and flaxseed oil supplementations in feed ratio of layers had positive impact on quality of eggshell. A very high positive correlation was found in eggshell strength ($r = 0.99$) and eggshell thickness ($r = 1.00$) to content of fat in feed mixture. In a previous study (Chetty et al., 2004), it was shown that essential oil supplementation could increase the concentration of calcium in the liver of non-ruminant animals. Vitamin D, which is a fat-soluble vitamin, has a direct effect on calcium absorption. Essential oil is considered to be a good solvent of vitamin D, and thus can improve calcium concentrations in eggshells (Bar et al., 1999). However, in present study significant differences in calcium and phosphorus contents between control and experimental groups in eggshell were not indicated (Table 3). Therefore it is clear that higher content of fat in diets is major factor which caused eggshell quality parameters in this trial. Similar results in comparison with present study were found by Zhang and Kim (2014) that researched effect of dietary olive oil on egg quality parameters of laying hens. Eggshell breaking strength and eggshell thickness were improved in the

Table 2 Eggshell strength and eggshell thickness

Group	Statistical parameter	Eggshell strength of bursting		Eggshell thickness
		mV	N cm ⁻²	mm
C	\bar{x}	0.41 ^a	21.76 ^a	0.28 ^a
	S.D.	0.04	2.12	0.03
	C.V. (%)	9.76	9.74	10.71
E1	\bar{x}	0.69 ^b	36.44 ^b	0.36 ^b
	S.D.	0.18	9.47	0.02
	C.V. (%)	26.09	25.99	5.56
E2	\bar{x}	0.67 ^b	35.49 ^b	0.36 ^b
	S.D.	0.2	10.65	0.03
	C.V. (%)	29.85	30.01	8.33

C – control group, E1 – pumpkin oil addition, E2 – flaxseed oil addition, \bar{x} – mean, S.D. – standard deviation, C.V. – coefficient of variance. Values with different superscript in a column are significant at the 0.05 level

treatment with addition olive oil (5% in feed mixture) as compared to the control. In the study Arpašová et al. (2014), who added oregano essential oil and into diets of layers, significant increase was recorded in eggshell thickness after oregano oil addition (1 ml kg⁻¹) compared to the control. Higher eggshell strength was found in experimental group (oregano oil) in comparison with control group ($P > 0.05$). In contrast, Cherian et al. (2009) studied effect of *Camelina sativa* (oilseed crop) in the diet of layer birds on egg parameters. Eggshell thickness of experimental eggs (5, 10 and 15% addition of *Camela* meal) was lower compared to the control eggs. However, differences among groups were not significant ($P > 0.05$). Shakoor et al. (2002), Shakoor et al. (2003) and Kucukersan et al. (2010) also showed non-significant changes of egg quality characters in laying hens fed diet supplemented with oils. Arpašová et al. (2015) who researched influence of different doses of essential oils

reported insignificant differences in eggshell strength and eggshell thickness. Eggshell strength was lower after thyme oil addition in diet (0.5 and 1 ml kg⁻¹) and higher after oregano oil addition in diet (1 ml kg⁻¹) compared to the control. Values of eggshell strength ranged from 27.17 (thyme oil addition) to 28.4 N cm⁻² (oregano oil addition). As regards eggshell thickness higher doses of thyme and oregano oils (1 ml kg⁻¹) in feed mixture had positive effect ($P > 0.05$). Similar findings to previous study found Botsoglou et al. (2005). Park et al. (2015) presented eggshell thickness of layers in the range from 0.37 to 0.40 mm. Tůmová et al. (2014) indicated average eggshell thickness of Lohmann Brown laying hens 0.31 mm.

The eggshell consists of 95% minerals, primarily calcium and others including phosphorus and magnesium (Sugino et al., 1997). Eggshells contain trace amounts

Table 3 Minerals composition of eggshell

Group		Ca	P	Mg	Na	K	Cu	Zn
		g kg ⁻¹						mg kg ⁻¹
C	\bar{x}	373.17ab	1.31	4.62a	1.12a	0.47a	2.14a	34.43
	S.D.	13.93	0.21	0.35	0.08	0.03	0.28	3.09
	C.V. (%)	3.73	16.38	7.48	7.18	7.47	13.18	8.93
E1	\bar{x}	343.83a	1.35	3.31b	0.81b	0.34b	1.67b	34.88
	S.D.	30.35	0.076	0.27	0.04	0.03	0.26	9.47
	C.V. (%)	8.83	5.63	7.39	5.47	8.68	14.95	27.15
E2	\bar{x}	389.17b	1.20	3.30b	0.82b	0.35b	1.75ab	41.10
	S.D.	37.23	0.10	0.14	0.03	0.02	0.17	16.60
	C.V. (%)	9.57	8.49	4.14	3.30	5.87	9.70	40.38

C – control group, E1 – pumpkin oil addition, E2 – flaxseed oil addition, \bar{x} – mean, S.D. – standard deviation, C.V. – coefficient of variance. Values with different superscript in a column are significant at the 0.05 level

of micro elements, i.e. magnesium, boron, copper, iron, manganese, molybdenum, sulphur, silicon and zinc. It is probably the best natural source of calcium and it is about 90% absorbable (Nys et al., 1999; Li-Chan and Kim, 2008).

Mineral composition of eggshell is summarized in Table 3. Significantly ($P < 0.05$) lower contents of magnesium, sodium, potassium and copper in experimental groups compared to the control were found in eggshell. Significant ($P < 0.05$) differences in content of calcium were detected only between E1 (pumpkin addition) and E2 (flaxseed addition). Tendency of a highest ($P > 0.05$) concentration of phosphorus after pumpkin oil supplementation and zinc after flaxseed oil supplementation were observed in eggshell.

The eggs produced by hens fed the control treatment (without experimental oil) were significantly different only from those derived from hens fed the diet supplemented with 2.5% canola oil + 2.5% soybean oil, which presented lower mineral content (Faitarone et al., 2013). The effect of dietary plant extracts added into feed mixture of layers on the content of phosphorus, calcium and magnesium in eggshell were not significant (Lokaewmanee et al., 2014). Herkel et al. (2016) also reported that phyto-genic additive including essential oil may significantly affect mineral composition in poultry products. Feeding olive oil along with conjugated linoleic acid completely prevented changes in the mineral content of eggs (Aydin et al., 2001). Average contents of Ca 344 g kg⁻¹, P 1.17 g kg⁻¹, Mg 3.32 g kg⁻¹ and Zn 4.82 g kg⁻¹ were observed in egg shell of Lohmann Brown laying hens (Tůmová et al., 2014).

4 Conclusions

Dietary intake of flaxseed and pumpkin oils in feed mixture positively affected quality of eggshell. Strength of bursting of shell and thickness of eggshell were markedly ($P < 0.05$) higher in both experimental groups compared to the control. The effect of essential oil supplementation in diets of laying hens influenced also mineral composition in eggshell. Evidently ($P < 0.05$) lower contents of magnesium, sodium and potassium in E1 (pumpkin oil addition) and E2 (flaxseed oil addition) and copper in E1 in comparison with control group were found in eggshell. The amounts of other minerals were relatively balanced among groups and were not considerably affected of oil addition in diet.

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References

- ANDJELKOVIC, M. et al. (2010) Phenolic compounds and some quality parameters of pumpkin seed oil. *European Journal of Lipid Science and Technology*, vol. 112, pp. 208–217. doi:<http://dx.doi.org/10.1002/ejlt.200900021>
- AOAC. (2000). *Official methods of analysis*. Washington: Association of official analytical chemists.
- ARPÁŠOVÁ, H. et al. (2014) The influence of oregano essential oil and *Rhus coriaria* L. on qualitative parameters and microbiological indicators of hens eggs content. *Scientific Papers: Animal Science and Biotechnologies*, vol. 47, no. 2, pp. 6–12.
- ARPÁŠOVÁ, H. et al. (2015) The effect of selected feed additives on the shell qualitative parameters of table eggs. *Scientific Papers: Animal Science and Biotechnologies*, vol. 48, no. 1, pp. 6–10.
- AYDIN, R., PARIZA, M. W. and COOK, M. E. (2001) Olive oil prevents the adverse effects of dietary conjugated linoleic acid on chick hatchability and egg quality. *The Journal of Nutrition*, vol. 131, no. 3, pp. 800–806.
- BAR, A., VAX, E. and STRIEM, S. (1999) Relationships among age eggshell thickness and vitamin D metabolism and its expression in the laying hen. *Comparative Biochemistry and Physiology – Part A: Molecular and Integrative Physiology*, vol. 123, pp. 147–154.
- BOTSOGLU, N. et al. (2005) The effect of feeding rosemary, oregano, saffron and alpha-tocopheryl acetate on hen performance and oxidative stability of eggs. *South African Journal of Animal Science*, vol. 35, no. 3, pp. 143–151.
- European Commission (2007): Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic and repealing regulation (EEC), 2092/91. *Official Journal*, L 189, 20/07/2007, pp. 1–23.
- FAITARONE, A. B. G. et al. (2013) Cholesterol levels and nutritional composition of commercial layers eggs fed diets with different vegetable oils. *Brazilian Journal of Poultry Science*, vol. 15, no. 1, pp. 31–38.
- HASHEMI, J. M. (2013) Pumpkin seed oil and vitamin E improve reproductive function of male rats inflicted by testicular injury. *World Applied Sciences Journal*, vol. 23, no. 10, pp. 1351–1359. doi:<http://dx.doi.org/10.5829/idosi.wasj.2013.23.10.13153>
- HERKEL, R. et al. (2016) The effect of a phyto-genic additive on nutritional composition of turkey meat. *Journal of Central European Agriculture*, vol. 17, no. 1, pp. 25–39. doi:<http://dx.doi.org/10.5513/JCEA01/17.1.1664>
- CHERIAN, G., CAMPBELL, A. and PARKER, T. (2009) Egg quality and lipid composition of eggs from hens fed *Camelina sativa*. *Journal of Applied Poultry Research*, vol. 18, pp. 143–150. doi:<http://dx.doi.org/10.3382/japr.2008-00070>
- CHETTY, K. N. et al. (2004) Garlic induced alteration in liver mineral concentrations in corn oil and olive oil fed rats. *Pathophysiology*, vol. 11, pp. 129–131.
- KOŇA, J., ĐUROVKA, M. and TANCÍK, J. (2007) *Pumpkin vegetables*. Nitra: Garmond. 148 p.
- KUCUKERSAN, K., YESILBAG, D. and KUCUKERSAN, S. (2010) Influence of different dietary oil sources on performance and cholesterol content of egg yolk in laying hens. *Journal of Biological and Environmental Sciences*, vol. 4, pp. 117–122.

- LI-CHAN, E. C. Y. and KIM, H. O. (2008) Structure and chemical composition of eggs. In: MINE, Y (Ed.). *Egg bioscience and biotechnology*, Wiley-Interscience, Hoboken, pp. 1–8.
- LOKAEWMANEE, K. et al. (2014) Eggshell quality, eggshell structure and small intestinal histology in laying hens fed dietary Pantoea-6 and plant extracts. *Italian Journal of Animal Science*, vol. 13, pp. 332–339. doi:<http://dx.doi.org/10.4081/ijas.2014.3163>
- NAGY, J. et al. (2009) *Hygiene of poultry meat, eggs and venison*. Košice: Editorial Centre of University of Veterinary Medicine, pp. 291–338.
- NYS, Y. et al. (1999) Avian eggshell mineralization. *Poultry and Avian Biology Reviews*, vol. 10, pp. 143–166.
- PANDA, A., RAMA, R. S. and RAJU, M. (2009) Phytobiotics, a natural growth promoter. *Poultry international*, vol. 48, no. 7, pp. 10–11.
- PARK, J. H., UPADHAYA, S. D. and KIM, I. H. (2015) Effect of dietary Marine Microalgae (*Schizochytrium*) powder on egg production, blood lipid profiles, egg quality, and fatty acid composition of egg yolk in layers. *Asian Australasian Journal of Animal Science*, vol. 28, no. 3, pp. 391–397. doi:<http://dx.doi.org/10.5713/ajas.14.0463>
- SHAKOOR, H. I. et al. (2002) Effect of feeding canola and soybean oils on serum lipid profile in commercial layers. *Pakistan Veterinary Journal*, vol. 22, pp. 48–51.
- SHAKOOR, H. I. et al. (2003) Comparative study on the effects of feeding canola and soybean oils on egg production and cholesterol in commercial layers. *Pakistan Veterinary Journal*, vol. 23, pp. 22–26.
- STEVENSON, D. G. et al. (2007) Oil and tocopherol content and composition of pumpkin seed oil in 12 cultivars. *Journal of Agricultural and Food Chemistry*, vol. 55, pp. 4005–4013.
- SUGINO, H., NITODA, T. and JUNEJA, L. R. (1997) General chemical composition of hen eggs. In: YAMAMOTO, T. et al. (eds.). *Hen eggs: Their basic and applied science*. New York: CRC Press, pp. 13–24.
- TŮMOVÁ, E., GOUS, R. M. and TYLER, N. (2014) Effect of hen age, environmental temperature, and oviposition time on egg shell quality and egg shell and serum mineral contents in laying and broiler breeder hens. *Czech Journal of Animal Science*, vol. 59, no. 9, pp. 435–443.
- ZELENKA, J. et al. (2008) The effect of dietary linseed oils with different fatty acid pattern on the content of fatty acids in chicken meat. *Veterinarni Medicina*, no. 2, pp. 77–85.
- ZHANG, Z. F. and KIM, I. H. (2014) Effects of dietary olive oil on egg quality, serum cholesterol characteristics, and yolk fatty acid concentrations in laying hens. *Journal of Applied Animal Research*, vol. 42, pp. 233–237. doi:<http://dx.doi.org/10.1080/09712119.2013.822815>
- ZHAO, G. et al. (2007) Dietary α -linolenic acid inhibits proinflammatory cytokine production by peripheral blood mononuclear cells in hypercholesterolemic subjects. *The American Journal of Clinical Nutrition*, vol. 85, no. 2, pp. 385–391.