Original Paper

Enrichment of table eggs with selenium and lutein – our experiences

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By modifying meals for hens it is possible to influence the content of selenium and lutein in eggs, which enables the production of eggs with an increased share of the desired functional ingredients. Such eggs on the market represent enriched or functional foods that are characterized by preventive action in order to preserve the human health. The results of our research show that the composition of meals affects the content of selenium and lutein in eggs. The use of Se-yeast in hens' mixtures in the amount of 0.5 mg·kg of feed increases the selenium content in egg whites and yolks by 62.94% and 41.54% in comparison to eggs from hens fed with a conventional mixture. Addition of 400 mg·kg of lutein to a hens' mixture can enrich egg yolk with lutein by 86.93% with respect to eggs from hens fed with a conventional mixture (without the addition of lutein).By designing hens' mixtures using selenium and lutein having antioxidant activity, it is possible to produce eggs with improved nutritional value and extended shelf life.

Keywords: eggs, enrichment, lutein, selenium

1 Introduction

Egg is an excellent source of proteins, vitamins and minerals. If the feeding of hens with specially designed mixtures increases the content of some nutrient substances in eggs, then such eggs are called enriched and can be considered a functional product. Consumption of such products may have a preventative effect on the preservation of human health. Selenium and lutein are antioxidants whose content in eggs increases proportionally to their increase in hens' mixtures (Surai 2000, Kralik et al., 2009, Grčević et al., 2014, Jing et al., 2015, Fašiangová et al., 2017, Kralik et al., 2018). The importance of selenium and lutein in human nutrition is multiple. Selenium is an integral part of more than 25 selenoproteins and some antioxidative enzymes (glutathione peroxidase – GPx and superoxide dismutase – SOD) and affects regulation of various physiological functions in the body (Kryukov et al., 2003). It prevents inflammatory processes, protects against UV rays and reduces the risk of atherosclerosis (Ferencik and Ebringer, 2003). Lutein is carotenoid present in the eye lens, and has a protective function from the occurrence of cataracts. It protects against oxidative damage and blindness. Lutein plays an important role in the prevention of age-related macular degeneration (AMD), a disease occurring in humans over the age of 65, a leading cause of blindness in the developed world. Lutein as an antioxidant reduces phototoxic damage to the protein and DNA of the eye lens (Gao et al., 2011). Given that the text outlines the range of benefits that arise when consuming eggs enriched with selenium and lutein, the aim of this paper is to show the possibilities of increasing their content in table eggs.

2 Material and methods

Increasing of selenium content in eggs

Selenium is found in nature in two forms, inorganic and organic. The inorganic form of selenium is sodium selenite, while the organic form of selenium used in poultry nutrition is Se-yeast and more recently different cereals bio-fortified with selenium. In feeding of hens for egg production, only the inorganic form of selenium was first used, while for a period of ten years organic form is used exclusively. The reason for the above was a series of studies that demonstrated better utilization of organic form of selenium from feed than inorganic form

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(Pan et al., 2007, Kralik et al., 2009, Jing et al., 2015, Kralik et al., 2016). It is known that microelements are present in traces in eggs, and mostly in egg yolk. Selenium is, however, specific in relation to other microelements because it is an integral part of a variety selenoprotein and is also incorporated into egg whites. In order to achieve the maximum increase of selenium in eggs, it is necessary to feed hens with specially prepared mixtures with increased levels of selenium during 4–5 weeks (Paton et al., 2002, Gajčević et al., 2009, Skřivan 2009, Jing et al., 2015). Skřivan (2009) states that if the inorganic form of selenium is added to feed for laying hens, it is possible to increase the selenium content in eggs from one and a half to two times compare to eggs produced without the addition of selenium to feed. However, if the organic selenium in the form of Se-yeast is added to feed, it is possible to increase the content of selenium in eggs at twice the level achieved by using sodium selenite. Many researchers in their papers point out the possibility of enriching eggs with selenium as well as placing such eggs on the market as enriched or functional foods. Paton et al. (2002) reported that it is possible to increase the selenium content in egg whites from 80 ng·g to 150 ng·g and in yolks from 320 ng·g to 480 ng·g, by feeding hens with mixtures containing 0.1 mg·kg or 0.3 mg·kg Se-yeast for a period of 33 days. Aljamal et al. (2014) suggest that the content of selenium in eggs increases in accordance with its content in feed. Thus, when hens are fed mixtures containing 0.2 mg·kg of selenium, the selenium content in egg whites is 2.33 mg·kg of dry matter and in yolks 1.57 mg·kg dry matter. The same authors state that increased selenium content in feed (0.4 mg·kg) increases the content of selenium in the edible part of the egg (egg whites = 2.93 mg·kg of dry matter and egg yolk = 1.63 mg·kg of dry matter).Table 1 shows the results of our research aimed at enriching of eggs with selenium.

Increasing of lutein content in eggs

Lutein is a plant pigment found in green leafy vegetables. It is main constituent of specific eye tissues like yellow

Table 1 The impact of selenium level and source on content of selenium in the edible part of the egg

Source of Se	Level of Se in feed (mg·kg)	Se content in egg white (mg·kg)	Se content in egg yolk (mg·kg)	Reference
Se-yeast	0.2	0.232	0.585	Gajčević et al. (2009)
	0.4	0.345	0.780	
Inorganic Se	0.2	0.181	0.573	Kralik et al. (2009)
Inorganic Se	0.4	0.230	0.757	
Se-yeast	0.4	0.345	0.783	
Bio-fortified corn	0.233	0.073	0.303	Kralik et al. (2017)
	0.426	0.207	0.626	
Inorganic Se	0.5	0.053	0.387	Kralik et al. (2018)
Se-yeast	0.5	0.143	0.662	

Table 2 Enrichment of eggs with lutein

Type of eggs	Lutein addition (mg·kg feed)	Lutein content (mg·60 g egg)	Reference
Free range eggs	0	0.55	Grčević et al. (2014)
Table eggs (producer 1)	0	0.24	
Table eggs (producer 2)	0	0.20	
Table eggs	0	0.20	Grčević (2015)
	200	1.38	
	400	1.53	
Omega-3 enriched eggs	0	0.33	
	200	1.62	
	400	1.78	
Designed eggs (enriched with omega-3, selenium, vitamin E, lutein)	0	0.19	Kralik et al. (2018)
	200	1.61	

spot (*macula lutea*) and eye lens. Since it has antioxidant properties and effectively filters high-energy blue light, it is very important for eye health. It is found that lutein is very important for central vision and visual acuity (Landrum and Bone, 2001) and that it has a crucial role in delaying of age-related macular degeneration, a major cause of blindness in older people (Gale et al., 2001). Lutein is soluble in fats and oils so it accumulates very well in the egg yolk, and this is also a reason for its better bioavailability from eggs then from other sources, like vegetables or food supplements (Chung et al., 2004). Its content in egg yolk can be affected by the addition of increased levels of lutein to laying hens' feed. An overview of own results on enrichment of eggs with lutein is presented in Table 2. From the results shown in the Table 2 it can be noticed that already 200 mg·kg lutein is enough for significant enrichment of eggs with lutein. Many different authors have been conducting research on enriching eggs with lutein. First of them were Leeson and Caston (2004) who studied the efficacy of transferring lutein from feed to the egg. They added lutein in corn-soy diets ranging from 0 mg·kg to 1,000 mg·kg, increasing the lutein level by 125 mg·kg for each subsequent treatment. The best effect of egg enrichment was achieved by addition of 500 mg·kg of lutein to the mixture. The content of lutein in egg increased from 0.16 mg per 60 g egg in group without lutein to 1.49 mg per 60 g egg with the addition of 500 mg·kg lutein.

In the research of Leeson et al. (2007) the maximum enrichment of egg with lutein was observed at the addition of 125 mg·kg of lutein to the mixture. Lutein level in egg rose from 0.09 mg per egg to 1.67 mg per egg, while further addition of 250 mg of lutein to the mixture did not affect the increase of lutein level in the egg (1.61 mg per egg). Golzar-Adabi et al. (2010) also investigated the effect of lutein supplemented to mixtures for laying hens on the content of lutein in eggs. They added 0, 250, 500 and 750 mg·kg of lutein to mixtures based on corn and soybean. Supplementation of 250 mg·kg lutein resulted in most significant increase of lutein level in egg, which rose from 0.12 mg per 57 g in control group to 1.35 mg per 57 g of egg in experimental group. The results of the above-mentioned research confirm the fact that the addition of lutein to hens' mixtures affects the level of lutein in the eggs, with the best results being achieved with an addition of not more than 500 mg·kg of lutein.

4 Conclusions

Different research in egg production has shown that it is possible to enrich eggs with selenium and lutein, while clinical studies have shown that eggs enriched with the specified ingredients can be functional foods. It is desirable to use eggs enriched with selenium and lutein in human nutrition to increase their daily intake into the body. In addition, increasing the content of selenium and lutein in eggs has a positive effect on the quality and freshness of the eggs.

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