1. Introduction

Yolk colour is the first parameter of yolk quality and generally ranks third amongst egg quality parameters, after freshness and eggshell quality. From the viewpoint of consumers, great emphasis is placed on the colour of yolk. Hens cannot synthesize the pigments and thus the feed mixtures are source of pigments. Moreover, synthetic carophylls are used for colouring effect of yolk, but in this case, the limits must be observed in terms of human health. Therefore, natural alternatives are searched, which will have a similar colouring effect and will not negatively affect the egg quality. Natural sources of carotenoids such as carrot, alga Cllorella, marigold or lutein increase the concentration of health-promoting carotenoids in yolks and increase the quality of eggs. For practical use, there must be taken into account the price of natural sources of carotenoids.

Keywords: carotenoids, carophyll, yolk colour, vitamins

2. Material and methods

2.1 Carotenoid lutein

Lutein is considered a protective nutrient against age-related macular degeneration in humans (Leeson et al., 2007). Dietary lutein supplementation at 250 mg kg\(^{-1}\) increased the lutein concentration in egg yolks from 0.12 to 1.35 mg per 57 g of egg mass (Golzar Adabi et al., 2010). Leeson and Caston (2004) showed that adding lutein at a concentration of 375 mg kg\(^{-1}\) to the diet of hens increased the lutein content of their yolks from 0.3 to 1.5 mg 60 g of egg. However, no further increase in yolk lutein content when the hens were fed a diet that was supplemented with above 375 mg kg\(^{-1}\) was observed. The transfer efficiency of lutein from feed to eggs was around 10 % with 125 mg kg\(^{-1}\) in the diet, declining to 2 to 3 % with 500 mg kg\(^{-1}\) (Leeson and Caston, 2004; Steinberg et al., 2000). In the subsequent experiment, the authors showed that the lutein content in egg yolks plateaued at 125 mg kg\(^{-1}\) diet, or 1.67 mg per egg (Leeson et al., 2007). In addition, Leeson et al. (2007) stated that eggs could be enriched with 1.6 mg of lutein per 60 g egg from a basal level of 0.10 mg per 60 g egg with the addition of natural lutein (250 mg kg\(^{-1}\)) to the diet. Lutein-enriched eggs have greater lutein bioavailability for humans than other supplements (Chung et al., 2004).

In the study of Englmaierová et al. (2013), lutein addition at 250 mg kg\(^{-1}\) significantly increased yolk colour, redness and yellowness contrary to control diet. Supplementation of feed with lutein significantly increased the concentration of lutein (from 12.8 to 133.9 mg kg\(^{-1}\) dry matter) and zeaxanthin (from 9.2 to 123.9 mg kg\(^{-1}\) dry matter) in the yolks. In addition, lutein addition significantly increased the oxidative stability of the lipids of fresh eggs and eggs that had been stored at 18 °C for 28 days. In another experiment, Englmaierová...
and Skřivan (2013) evaluated the effect of lutein addition at 100 mg kg\(^{-1}\) on egg quality. The addition of lutein also increased the yolk colour and the redness and yellowness value of the yolks. Compared with the control group, supplementing the diets with lutein significantly increased the concentrations of \(\beta\)-carotene by 66 %, lutein by 97 %, and zeaxanthin by 94 % in the egg yolks, respectively. Commercially available lutein is too expensive and therefore inapplicable in practice. Thus the aim is to find a cheap source of carotenoids, especially lutein.

### 2.2 Natural sources of carotenoids and their effect on egg quality

Based on the still unpublished results, marigold seems to be less expensive source of carotenoids. Marigold (Tagetes erecta L.) is a rich source of xanthophylls, particularly the lutein (80 to 90 %) (Quackenbush and Miller, 1972). Lokaewmanee et al. (2011) showed that the lutein from marigold improves egg yolk colour when supplemented at levels of around 30 to 40 mg kg\(^{-1}\), and saponified lutein from marigold flower extract appears to be more effective in egg yolk colour than non-saponified lutein from marigold flower meal.

Another source of carotenoids may be carrots. The effect of three coloured carrot varieties on egg yolk colour and deposition of carotenoids in the yolk was evaluated by Hammershøj et al. (2010). Supplementing the feed of egg-laying hens with coloured carrots at 70 g per hen per day efficiently increased yolk colour parameters and total carotenoids content, especially lutein, \(\alpha\)-carotene and \(\beta\)-carotene content. The lutein concentration in yolks increased from 7.5 to 8.2–12.2 mg kg\(^{-1}\), and the concentration of total carotenoids was increased from 10.8 to 14.0–20.2 mg kg\(^{-1}\). The deposition efficiency of lutein and zeaxanthin from feed to egg yolk was significantly increased by 66 %, lutein by 97 %, and zeaxanthin by 94 % in the control group, supplementing the diets with lutein also increased the yolk colour and the redness of the egg yolk examined Dumbravá et al. (2006). The stronger absorption was observed in the case of dihydroxy xanthophylls (lutein, zeaxanthin) and weaker in the case of carotenoidal hydrocarbons (\(\alpha\)-carotene, \(\beta\)-carotene). As is evident from experiment of Englmaierová and Skřivan (2013), the inclusion of 10 g kg\(^{-1}\) of mustard meal in the diet affected the yolk colour in a manner similar to lutein addition at 100 mg kg\(^{-1}\).

### 3. Conclusions

From the present studies, it can be concluded that natural sources of carotenoids increase the concentration of health-promoting carotenoids in yolks and increase the quality of eggs. Therefore, they are a suitable alternative to commercial synthetic carotenoids.

### 4. Acknowledgements

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### 5. References


