Acta fytotechn. zootechn., 17, 2014(2): 55–57

Original Paper

Received 9. May 2014 | Accepted 29. May 2014 | Available online 23. June 2014

Carotenoids and egg quality

Michaela Englmaierová*, Ivana Bubancová, Miloš Skřivan

Institute of Animal Science, v.v.i., Prague-Uhříněves, Czech Republic

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 *Chlorella*, 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

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, darker yolks are required. Hens, like all animals, cannot synthesize the pigments. But they can store the pigments obtained from the diet. Carotenoids are a source of red and yellow pigments which alter egg yolk colour. The pigmenting efficiency depends on the digestibility, transfer, metabolism and deposition of carotenoids in target tissue and upon their colour hue. The carotenoids are highly unstable products and there have been tremendous efforts to produce more concentrated and stabilised sources (Nys, 2000).

In particular, various synthetic carotenoids, such as ethyl ester of β-apo-8'-carotenoic acid and canthaxanthin known as Carophyll Yellow and Carophyll Red, are used for colouring of egg yolk. But canthaxanthin is considered as one of the potentially hazardous substances for human health. For laying hens feeds, canthaxanthin should not exceed 8 mg kg^{-1} since at extremely high dosages minute crystals may be formed in the retina by a reversible deposition process (Breithaupt, 2007). Therefore, interest in natural alternatives has increased.

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

***Correspondence:** Ing. Michaela Englmaierová, Ph.D., Institute of Animal Science, v.v.i., Přátelství 815, 104 01 Prague 10-Uhříněves, Czech Republic. Phone: +420 267 009 547, fax +420 267 710 779, e-mail: englmaierova.michaela@vuzv.cz

Faculty of Agriobiology and Food Resources, 2014
http://www.fapz.uniag.sk/
DOI: 10.15414/afz.2014.17.02.55–57

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 β-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, α-carotene and β-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 approximately 25 %, and the deposition efficiency of β-carotene was only 0.5 %.

Fredriksson et al. (2006) tested the addition of the marine microalgae *Nannochloropsis oculata* at 20 % of the dry matter (DM) diet of hens. The lutein and zeaxanthin content in the eggs after 4 weeks of feeding was 22 mg kg^{-1}, i.e., 1.32 mg per 60 g of egg. Kotrbáček et al. (2013) showed that diets supplemented with 10 and 20 g kg^{-1} dry *Chlorella* biomass significantly increased egg yolk deposition of total carotenoids by 46 and 119 %. The maximum concentrations were achieved after four weeks of supplementation and exceeded 25 and 40 mg per g of yolk, respectively. Supplementation of feed with *Chlorella* significantly increased the concentration of lutein (from 12.8 to 49.0 mg kg^{-1} dry matter) and zeaxanthin (from 9.2 to 40.1 mg kg^{-1} dry matter) in the yolks (Englmaierová et al., 2013). The effect of seabuckthorn berry flour on the degree of the carotenoids accumulation in the egg yolk examined Dumbravă et al. (2006). The stronger absorption was observed in the case of dihydroxy xanthophylls (lutein, zeaxanthin) and weaker in the case of carotenoidic hydrocarbons (α-carotene, β-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

This study was supported by the Ministry of Agriculture of the Czech Republic (Project QJ1310002 and MZERO0714).

5. References

BREITHAUPT, D. E. (2007) Modern application of xanthophylls in animal feeding – a review. In *Trends in Food Science and Technology*, vol. 18, no. 10, pp. 501–506.
DOI: http://dx.doi.org/10.1016/j.tifs.2007.04.009.

CHUNG, H. Y., RASMUSSEN, H. M. and JOHNSON, E. J. (2004) Lutein bioavailability is higher from lutein-enriched eggs than from supplements and spinach in men. In *Journal of Nutrition*, vol. 134, no. 8, pp. 1887–1893.

DUMBRAVĂ, D. et al. (2006) Effect of seabuckthorn berry flour from hens food on egg yolk carotenoidic pigments content. In *Annals of the Faculty of Engineering Hunedoara*, vol. 3, pp. 156–160.

ENGLMAIEROVÁ, M., SKŘIVAN, M. and BUBANCOVÁ, I. (2013) A comparison of lutein, spray-dried *Chlorella*, and synthetic carotenoids effects on yolk colour, oxidative stability, and reproductive performance of laying hens. In *Czech Journal of Animal Science*, vol. 58, no. 9, 412–419.

ENGLMAIEROVÁ, M. and SKŘIVAN, M. (2013) Effect of synthetic carotenoids, lutein, and mustard on the performance and egg quality. In *Scientia Agriculturae Bohemica*, vol. 44, no. 3, 138–143.
DOI: http://dx.doi.org/10.7160/sab.2013.440303.

FREDRIKSSON, S., ELWINGER, K. and PICKOVA J. (2006) Fatty acid and carotenoid composition of egg yolk as an effect of microalgae addition to feed formula for laying hens. In *Food Chemistry*, vol. 99, no. 3, pp. 530–537.
DOI: http://dx.doi.org/10.1016/j.foodchem.2005.08.018.

GOLZAR ADABI, S. H. et al. (2010) Quantification of lutein in egg following feeding hens with a lutein supplement and quantification of lutein in human plasma after consumption of lutein enriched eggs. In *Archiv fur Geflugelkunde*, vol. 74, no. 3, pp. 158–163.

HAMMERSHØJ, M., KIDMOSE, U. and STEENFELDT, S. (2010) Deposition of carotenoids in egg yolk by short-term supplement of coloured carrot (*Daucus carota*) varieties as forage material for egg-laying hens. In *Journal of the Science of Food and Agriculture*, vol. 90, no. 7, pp. 1163–1171.
DOI: http://dx.doi.org/10.1002/jsfa.3937.

KOTRBÁČEK, V. et al. (2013) Retention of carotenoids in egg yolks of laying hens supplemented with heterotrophic *Chlorella*. In *Czech Journal of Animal Science*, vol. 58, no. 5, pp. 193–200.

LEESON, S. and CASTON, L. (2004) Enrichment of eggs with lutein. In *Poultry Science*, vol. 83, no. 10, pp. 1709–1712. DOI: http://dx.doi.org/ 10.1093/ps/83.10.1709.

LEESON, S., CASTON, L. and NAMKUNG, H. (2007) Effect of dietary lutein and flax on performance, egg composition and liver status of laying hens. In *Canadian Journal of Animal Science*, vol. 87, no. 3, pp. 365–372.
DOI: http://dx.doi.org/10.4141/A06-043.

LOKAEWMANEE, K. et al. (2011) Enhancement of Yolk Color in Raw and Boiled Egg Yolk with Lutein from Marigold Flower Meal and Marigold Flower Extract. In *Journal of Poultry Science*, vol. 48, no. 1, pp. 25–32. DOI: http://dx.doi.org/10.2141/jpsa.010059.

NYS, Y. (2000) Dietary carotenoids and egg yolk coloration – a review. In ARCHIV FUR GEFLUGELKUNDE, vol. 64, no. 2, pp. 45–54.

QUACKENBUSH, F.W. and MILLER, S. L. (1972) Composition and analysis of the carotenoids in marigold petals. In *Journal of the Association of Official Analysis Chemists*, vol. 55, no. 3, pp. 617–621.

STEINBERG, W. et al. (2000) Comparative pigmentation efficiency of two products containing either apo-ester or tagetes extracts in egg yolks and liquid eggs. In *Archiv fur Geflugelkunde*, vol. 64, no. 4, pp. 180–187.

Faculty of Agriobiology and Food Resources, 2014
http://www.fapz.uniag.sk/
DOI: 10.15414/afz.2014.17.02.55–57