Absorption of carotenoids (lycopene, lutein, beta-cryptoxanthin) in newly-hatched chick

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The evaluation of carotenoid metabolism in human/animal is becoming common practice. Epidemiological studies show that adequate consumption of fruits and vegetables containing carotenoids is in correlation with the reduction of risks related to the evolvement of cancers. Carotenoids have great importance in poultry as well. The absorption a few natural carotenoids (lycopene, lutein, β-cryptoxanthin) was investigated in day old chickens at 0-72 hours of age, concerning absorption areas and volume. Natural carotenoids (5 ppm xanthophyll mixture (0.152 g Capsantal EBS 40 NT: extraction of Tagetes erecta; active substances: 40 g/kg yellow xanthophyll: 0.8 % β-carotene, 1.5 % cryptoxanthin, 82.0 % trans-lutein, 4.0 % trans-zeaxanthin, 11.7 % other carotenoids) and 5 ppm lycopene (0.012 g dehydrated paste of tomato) in 0.5 ml sunflower oil emulsion) were provided per os. Chickens were sacrificed and bled in 0th, 2nd, 4th, 6th, 8th, 24th, 36th, 48th and 72nd hours, respectively. Serum, yolk sac and liver were prepared. Carotenoid profile was determined with HPLC by normal phase isocratic elution on Rocket Platinum column (Alltech Inc.) preceding direct extraction. Lycopene was not detected as component neither from serum nor from liver carotenoids. Lutein values were decreased in yolk, while rose in liver and serum by the 24th hour. The carotenoid profile in control birds was similar to treated chickens. The absorption surface of duodenum and ileum was saturated by yolk materials which passed via yolk stalk and the antiperistaltic movement up to 72 h posthatch. For these reasons the effective absorption of per os provided carotenoids was hindered.

Keywords: carotenoids (lycopene, lutein, β-cryptoxanthin); absorption; newly-hatched chick

Introduction

Carotenoids are known to provide a range of biological effects (provitamin, antioxidant, coloring etc.) to a variety of animals. Lutein (3,3′-dihydroxi-alpha-carotene)(Lu) constitutes up to 85 to 90% of marigold (Tagetes erecta) carotenoids are used as a cheap source of carotenoids in feeding of hens for yolk and skin coloration. After the absorption, lutein is detected in the different chicken tissues (Gomez et al. 1978). Plasma carotenoid of chickens achieved after feeding diets containing xantophylls (lutein, β-cryptoxanthyn (BCx)) and other carotenoids and no matter if free or esterified carotenoids were fed (Breithaupt et al. 2003). The content of intestinal tracts of young chicks, fed a yellow corn-soy-based diet from hatching until 3-weeks-old, was analyzed for content of different xantophylls (zeacarotene, cryptoxanthin, and lutein). Cryptoxanthin was poorly absorbed by young chickens, served as a nonabsorbed reference material. The finding of different sites of absorption for zeacarotene and lutein, combined with the poor absorption of cryptoxanthin, suggests the existence of regulatory mechanisms for carotenoids in chickens (Tyczkowski et al. 1986). Carotenoids in the diet of the laying hen are incorporated into the egg yolk and subsequently into the liver and other tissues of the chicken embryo. Karadas and coworkers (2005) compared the effectiveness of the hen's diet and the progeny's diet supplementation with carotenoids on the carotenoid status of the chick during the
first 4 weeks of post-hatch life. The concentration of carotenoids in the livers of chicks hatching from the enriched eggs was initially 29 times greater than in the control chicks and maintained post-hatch on the control diet for at least the first 7 days. The maternal effects predominate for at least the first week after hatching.

Since the antioxidant and immunostimulatory effects of carotenoids are especially important during the immediate post-hatch period, and important for the viability of the offspring (Karadas et al. 2005). Lycopene (Ly) is a member of the carotenoid family as an acyclic isomer of beta-carotene but has no vitamin A activity. This dye is responsible for the red color of tomato and its products. Beside the coloration effects lycopene has one of the highest antioxidant activity of all the carotenoids (Rao and Agarwal 1998) but non-antioxidant mechanisms have also been proposed such as upregulation of gap junction protein expressions (Forbes 2003), suppression of phosphorylation, inhibition of cholesterol synthesis and cell division (Agarwal and Rao 1998). Because lycopene has some health benefits a lot of studies focused its effects. Most of the studies deal with the aspects of human health (i.e. prostate and lung cancer) and less in animal science.

In present study it was investigated whether the p.o. carotenoid (Lu+BCx and Ly) supplementation of newly hatched chicken is able to increase the carotenoid reserve of young chick.

**Materials and methods**

The absorption a few natural carotenoids (lycopene, lutein, β-cryptoxanthin) was investigated in newly hatched chickens at 0-72 hours of age, concerning absorption areas and volume. Natural carotenoids were provided per os: 5 ppm xanthophyll mixture (0.152 g Capsantal EBS 40 NT: extraction of Tagetes erecta; active substances: 40 g/kg yellow xanthophyll: 0.8 % β-carotene, 1.5 % cryptoxanthin, 82.0 % trans-lutein, 4.0 % trans-zeaxanthin, 11.7 % other carotenoids) and 5 ppm lycopene (0.012 g dehydrated paste of tomato) in 0.5 ml sunflower oil emulsion. Chickens were sacrificed and bled in 0th, 2nd, 4th, 6th, 8th, 24th, 36th, 48th and 72nd hours, respectively. Serum, yolk sac and liver were prepared.

In the 2nd experiment 200µg lycopene (Redivivo™ (lycopene) 5% TG/P, DSM) dissolved in 0.5 ml of body warm physiological salt solution was injected into the yolk sac of 15 newly hatched chickens (0h). The animals were sacrificed 24, 48 and 72 hs later and the sera were analyzed for lycopene content.

Carotenoid profile was determined with HPLC by normal phase isocratic elution on Rocket Platinum column (Alltech Inc.) preceding direct extraction (Kerti and Bárdos 2006). The effluent was monitored on appropriate wavelength of each component by four channel detector (UV-2077 Plus Jasco).

**Results and discussion**

Lycopene was not detected as component neither from serum nor from liver carotenoids. The dominant carotenoids of investigated tissues (plasma, liver and yolk sac) were the lutein (Lu) and
zeaxanthin (Zx). These two compounds (4+5) were eluted nearly in the same position of our HPLC system (Fig.1). The another characteristic carotenoid was according to our results the β-cryptoxanthin (BCx). The numeric values in µg/g (liver and yolk) and µg/l (plasma) were drawn in Fig.2 and Fig.3.

Figure 2. Concentrations of β-Cryptoxanthin in serum, liver and yolk sac of chickens

Figure 3. Concentrations of Lutein/Zeaxanthin in serum, liver and yolk sac of chickens
In the graphs the calculated polynomial regression lines express the tendencies of concentrations of investigated carotenoids in the blood plasma, liver and yolk sac of chickens in the first three days. The Lu/Zx and BCx concentrations of yolk sac were slightly increased up to the 6th h. These elevations were caused by the concentration of yolk materials due to the beginning of the transport processes from yolk to blood and intestine, respectively. From 6th h to the end of investigated period (72nd h) the concentrations of these carotenoids decreased continuously. The concentration of carotenoids in blood and liver was increased during the first three days indicating the continuous transport from yolk to liver via blood plasma. In the case of Lu/Zx the elevation was more characteristic than BCx which confirmed that the BCx poorly absorbed in chick (Tyczkowski et al. 1986).

The carotenoid profile in control birds was similar to treated chickens i.e. the carotenoid concentrations of blood plasma were not proportional with the doses applied. Lycopene which was given in the applied cocktail was undetectable in the blood. Probably it was happened because the absorptive surface of upper small intestine was covered by yolk sac material. Beside the vascular transport by yolk sac membrane the yolk materials regularly pumped into the small intestine across the yolk stalk (Noy and Sklan 1998). For this reason because of the upper small intestine is occupied by yolk material i.e. the p.o. given carotenoid could not able to reach the absorptive surface. The ineffective absorption of orally given carotenoid doses could be explained by this phenomenon.

For the test of this hypothesis Ly solution (200 µg in 0.5 ml of physiological salt solution) was injected into yolk sac of newly hatched chicken in the 2nd experiment. Under normal conditions this acyclic carotenoid (Ly) is not present among the carotenoids of egg yolk. Nevertheless tomato originated Ly absorbed from the intestine and transported into ovary in Japanese quail according our results. This phenomenon was proven in our previous experiment (Bárdos et. al 2004) in which significant increase of YCF values were detected. Ly was detected in decreasing manner from the blood plasma of the injected chick in 24th, 48th and 72nd hs. Our hypothesis was confirmed by this result.

References


