



Carotenoids in breeders as antioxidant and for immunomodulatory protection in chicks

The use of carotenoids in poultry goes far beyond pigmentation. Carotenoids provide antioxidant and immune enhancement effects, and eventually allows improving the productive performance.

The use of carotenoids for yolk, skin and leg pigmentation is a common practice in poultry production. Lutein and zeaxanthin are naturally present in many feedstuffs like alfalfa or corn and are the main carotenoids naturally present in the yolk (>80%). That is why they are also supplemented as feed supplements in diets lacking suitable levels. Other natural (capsanthin) and synthetic (cantaxanthin or ethyl ester of beta-apo-8'-carotenoic acid) carotenoids can also be supplemented.

In addition to their pigmentation abilities, carotenoids are also involved in important biological functions of the animal. Their antioxidant and immunological effects are well known and the improvement on productive performance is well established, especially related to reproductive efficacy and chick viability, as well as precursors of vitamin A.

In the following paragraphs we review the biological role of carotenoids beyond their pigmentation properties.

How do carotenoids prevent oxidative tissue damage?

Carotenoids are natural antioxidants and very efficient quenchers of singlet O₂ and free radicals. This ability confers carotenoids **a key role in tissue protection against oxidative stress**. This process occurs when the organism is not able to properly metabolize all the metabolites derived from natural oxidative reactions. As a result, these metabolites accumulate in tissues and induce cell damage, mainly affecting cell membranes, proteins, carbohydrates and DNA.

To some extent, all carotenoids have shown this antioxidant protection in tissues. However, there is certain variability on the effect depending on the species and target tissues. Gao *et al.* (2013) assessed the use of a lutein-zeaxanthin mixture in breeder diets (Table 1) and showed that in chicks from supplemented hens, an important increase of enzymes favoring the elimination of free radicals occurred.

Table 1. Concentrations of antioxidant enzymes in the liver of chicks hatched from hens fed diets with or without carotenoids (lutein +zeaxanthin) (Gao *et al.*, 2013)

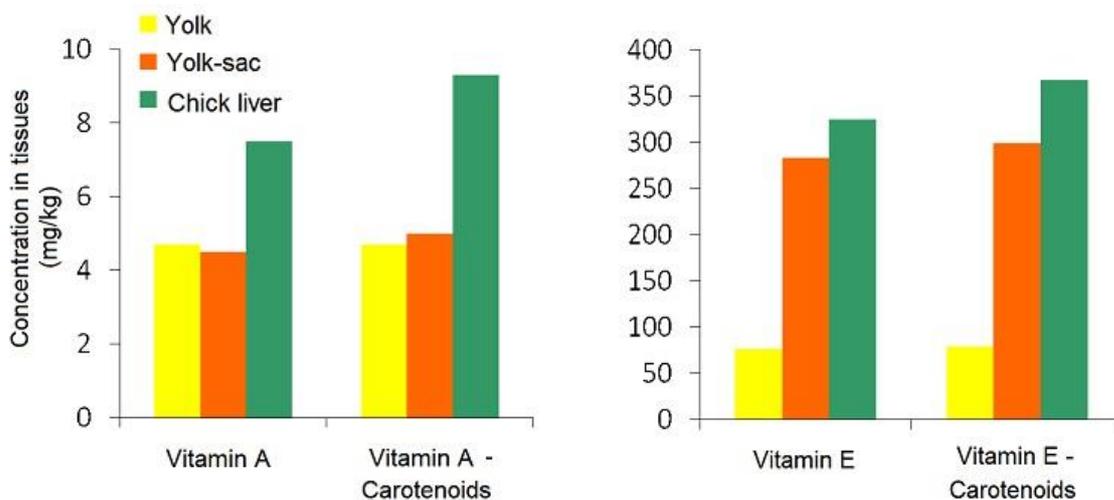
	Breeder diet (+)	Breeder diet (-)
Glutathione peroxidase (U/mg)	672,0 ^a	538,6 ^b
Total antioxidant capacity (U/mg)	2,39 ^a	1,37 ^b
Glutathione oxidase (U/mg)	15,09	10,68
Malonaldehyde (nmol/mg)	2,60 ^a	3,47 ^b

^{a,b} Means with different superscripts within a row differ significantly ($P < 0.05$)

Some carotenoids such as β -carotene **are also vitamin A precursors**, therefore enhancing the absorption and deposition of this vitamin in the egg. In fact, vitamin A is an essential nutrient for the normal development of the embryo, affecting the early stages of the cardiovascular system that will subsequently allow the embryo to get all the nutrients from the yolk. On the other hand, the levels of vitamin E are also increased due to the antioxidant activity of carotenoids, which prevent the oxidation of this vitamin. In fact, vitamin E is one of the main antioxidants for tissue oxidation control.

In a study by Surai & Speake (1998) the authors show the important provitamin A activity of carotenoids in egg and embryo tissue of chicks from hens supplemented with antioxidants. Figure 1 clearly shows how vitamins A and E in chicken embryo liver are significantly increased in those chicks from breeders supplemented with carotenoids (Fig. 1).

Figure 1. Concentrations of vitamin A and E in eggs and chicken embryo obtained from hens fed diets enriched with or without carotenoids (Surai and Speake, 1998)

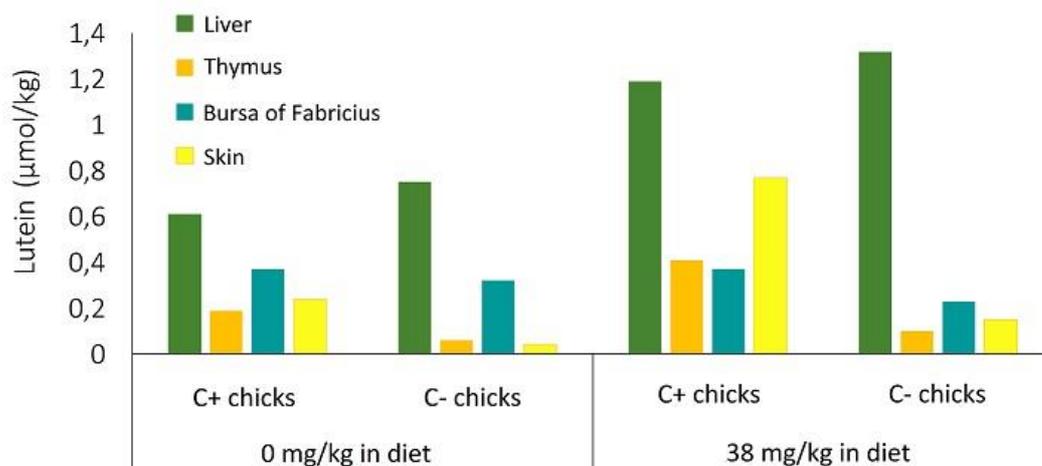


Immunologic effects of carotenoids

The effects of carotenoids in the immune system are also remarkable both in the innate and the acquired (humoral and cellular) components of immunity. These effects help to prevent infectious and inflammatory processes. These **immunomodulatory properties** are related to the antioxidant activity and mainly due to effects on free radicals in leukocytes.

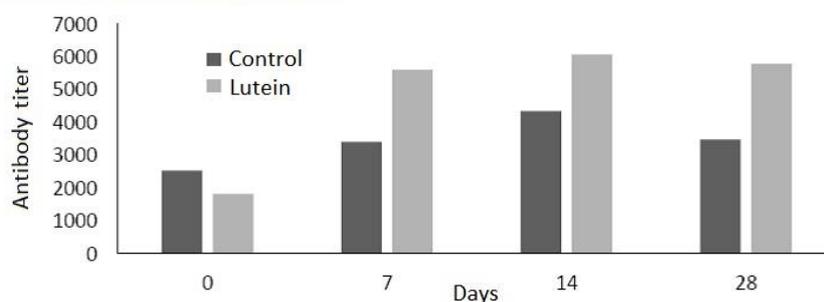
In avian species, carotenoids tend to accumulate in immune organs. Koutsos *et al.* (2003) showed a significant accumulation in thymus and bursa of chicks when carotenoids were included in the breeders diet. Moreover, those carotenoids coming from hen's diet were still detected 4 weeks after hatching in chickens fed carotenoid depleted diets. On the other hand, those chickens coming from supplemented hens, showed a higher ability to store carotenoids in tissues (Figure 2).

Figure 2. Effect of the carotenoids in the breeder's diet on the carotenoid deposition in chick tissues (Koutsos et al., 2003)



Finally, supplementation with carotenoids in the diet results in an increase of antibody production in response to infectious challenges in breeders (Figure 3).

Figure 3. Antibody titer in hens with or without carotenoids in the diet, and vaccinated against IBV (Bedecarrats and Lesson, 2006)





High efficacy of carotenoids to improve productive performance

In addition to the benefits described above, carotenoids have also shown to **improve the productive parameters, especially those related to reproduction**. So, the presence of carotenoids in eggs has been associated to a higher hatchability and a higher viability of the hatched chicks. Supplementation of breeder's diets has been also related to better sperm quality and higher fertility (Suri *et al.*, 2006).

In a trial involving 200 hens (Ross-308) of 35 weeks of age, the supplementation with a carotenoids (20 mg/kg) and a vitamin mixture showed an increase in fertility, hatchability, and chick viability from the very first week. Differences did not reach significance due to sample size though (Table 2).

Table 2. Effects of a carotenoid + vitamin complex on chick viability

	Control	Carotenoids
Fertility (%)	95,1	96,8
Hatchability of fertile eggs (%)	88,8	90,4
Embryonic mortality (%)	8,6	7,2
Chick mortality at 1 week (%)	1,9	0,2

In summary, **the addition of carotenoids to the diet** allows achieving an **adequate pigmentation of eggs and chickens**, but also provides **antioxidant and immunoestimulatory effects** as well as an important **improvement of the productive performance** of the animals, especially the **reproductive efficacy**.

Based on these evidences, **ITPSA** has developed the range of products **CAPSOBIOL**, formulated with carotenoids, vitamins and minerals of high bioavailability. The objective of these lines of products is **to improve the reproductive efficiency of the breeders and the viability of the offspring**.