The role of carotenoids in breeding poultry

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Carotenoids are essential ingredients in animal feed. They are not only important as pigments but serve as health promoting antioxidants and as a precursor of vitamin A. Because of their importance in visual perception of animal products, such as eggs, and their central role in health and well being of the animal, carotenoid content needs to be carefully monitored.

Carotenoids are present in the animal kingdom, yellow, orange and red and are typically associated with birds such as seagulls and pink floyds. The colour carotenoids give to a numbers of birds affects some biological functions such as sexual behaviour and health indicators.

The observation that many avian species in the wild naturally deposit very high concentrations of carotenoids into their yolks could imply that these pigments are there for a purpose.

Amongst natural antioxidants, carotenoids play important roles in avian reproduction by maintaining antioxidant defences of the spermatozoa and embryonic tissues.

Increased carotenoid concentration in the chicken embryo decreased the susceptibility of the tissues to lipid peroxidation. Dietary supplementation with antioxidants exerts a positive effect on fertility in aging hens by increasing their capacities for sperm retention at the sperm storage tubule level.

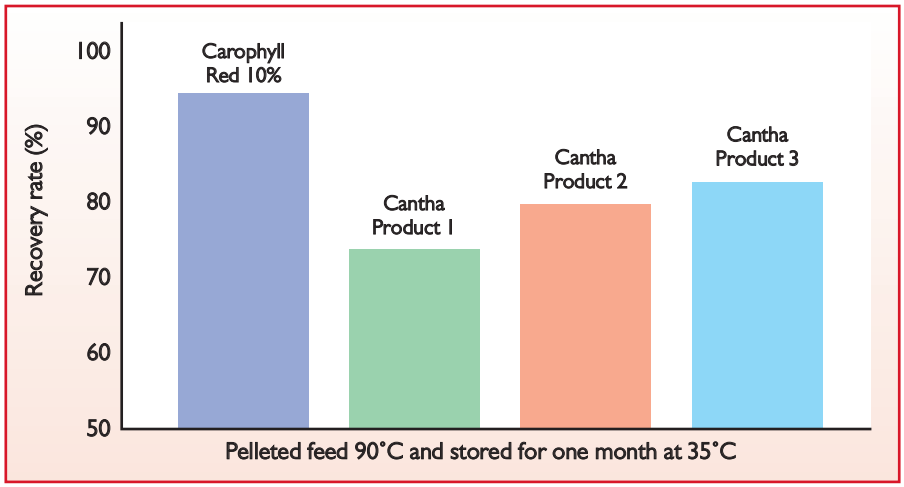

Fig. 1. Stability of Carophyll Red 10% compared to three canthaxanthin products in a pelleted feed (90°C) stored for one month (35°C, 60% humidity).

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.

By transferring large amounts of dietary yellow and red carotenoids to the egg yolk, the mother provides protection for the developing embryo against oxidative damage. Indeed, eggs from wild birds contain carotenoid levels which are 3-10 times higher than the common levels in commercial eggs.

In wild birds, loss of egg yolk or skin pigmentation is associated with disease, sickness or nutritional deficiencies.

The antioxidant and immunostimulatory effects of carotenoids are especially important during the immediate post-hatch period, and important for the viability of the offspring. Maternal effects persist for at least the first week after hatching, thereafter the progeny's diet becomes the main determinant of its carotenoid status.

Since the antioxidant and immunostimulatory roles of carotenoids are likely to be especially important during the immediate post hatch period, maternal dietary intake of carotenoids may have important ramifications for the viability of the offspring.

Benefits of canthaxanthin

Canthaxanthin is one of the more efficiently deposited carotenoids in the egg yolk and this explains the reason why DSM has selected this carotenoid for poultry feed application.

Hoppe and Krennrich (1995) reported deposition rates in egg yolk for canthaxanthin of 39%. Canthaxanthin is routinely fed

Continued on page 21

Table 1. Summary of field trials results with 6ppm canthaxanthin.

Country	Date	Diet	Number of birds	Duration (weeks)	Age (weeks)	Breed	More chicks (%)	Return on investment € for €1 invested
Brazil	2007	Sorghum soya	13,095	8	45	Avian 48	3.6	11.5
France	2005	Corn soya	10,575	9	33	White strain	2.1	6.9
						Yellow strain	1.9	6.2
Netherlands	2007	Wheat soya	1,800	7	46	Ross	0.7	2.3
Japan	2006	Corn soya	624	6	27	Ross	4.1	13.5

Continued from page 19
to laying hens up to increase the colour of the egg yolk in order to match consumer preferences.

The unique product formulation of Carophyll Red 10% makes canthaxanthin more resistant to aggressive factors, achieving optimal stability by double protection: the carotenoids are stabilised with antioxidants and embedded in an innovative plant-based beadlet formulation (patent EP 0-565-989).

It has been proven in customer trials that the carophyll product form can resist aggressive conditions when sterilisation is applied to feed for poultry breeders.

Carophyll Red 10% was significantly better deposited in the egg yolk and more stable than other canthaxanthin products. A new comparison of Carophyll Red 10% with competitors' products (Fig. 1) confirms better stability after pelleting and storage for one month.

Canthaxanthin is a potent radical scavenger and nature's most powerful lipid soluble antioxidant. The biological functions of canthaxanthin will be related, at least in part, to its ability to function as an anti-oxidant (free radical scavenging/vitamin E sparing) in animal tissues.

The anti-oxidant characteristics of canthaxanthin have been studied by a number of authors and experiments have shown that the presence of canthaxanthin can potentially help to reduce oxidation in a number of tissues including broiler meat and the chick embryo.

In the egg, canthaxanthin is transferred from yolk to the developing embryo where it might help to protect the developing bird against oxidative damage, particularly during the sensitive periods of hatching and early posthatch life.

In this regard, it is interesting to note that Llauradó et al. (1997) reported that canthaxanthin improved the hatchability of eggs (number of chicks hatched per 100 fertile incubated eggs) in broiler breeder hens.

In this study, hens were fed a diet containing different levels of canthaxanthin (0, 2, 4, or 6mg/kg) from 26-39 weeks of age.

Increasing dietary canthaxanthin levels improved mean hatchability rates in weeks 34-39 from 85.5% in the control group (0mg/kg) to 88.5% (2mg/kg), 88.5% (4mg/kg) and 91.1% (6mg/kg) in those groups receiving canthaxanthin.

In the study of Surai et al, 2003, run with Ross breeders, the results supports the view that maternally derived canthaxanthin in the yolk not only exerts effects directly during the embryonic period but also has repercussions at various stages of post-hatch life.

Canthaxanthin was transferred from the egg yolk to the developing embryo and, as a result, its concentration in the liver of the embryo at 16 days and in one day old chicks was increased. Even at day seven posthatch canthaxanthin concentration in the chicken liver was elevated.

Canthaxanthin supplementation of the maternal diet at 12mg/kg was associated with an increased α-tocopherol concentration in the liver of one day old chicks and resulted in decreased tissue susceptibility to lipid peroxidation.

Canthaxanthin supplementation at 6-24mg/kg was also associated with a delay in α-tocopherol depletion from the liver for seven days posthatch.

As a result of the increased canthaxanthin and vitamin E concentrations in the liver of seven day old chicks, tissue susceptibility to lipid peroxidation decreased.

In a field trial reported by Robert et al, 2007, two buildings of 9000 Ross PM 3 breeders were fed with 6ppm canthaxanthin for 12 weeks, from 27 to 38 weeks of age and without canthaxanthin.

The feed was heat treated and composed of wheat, corn and soya meal. Blood samples were taken from one day old chicks.

The antioxidant status of the sera of the chicks derived from breeders fed with canthaxanthin was significantly higher and the TBARs level was significantly lower. These results indicated that 6ppm canthaxanthin in the maternal diet can enhance the antioxidant status and depress oxidative stress of the day old chicks.

Practical field experiences

Souza et al (2008) recently reported very positive results in Brazil. A total of 13,095 breeders broilers of 45 weeks were fed with a diet composed of sorghum and soya bean meal. The results were recorded after eight weeks of supplementation with Carophyll Red 10% compared to the control diet. Fertility and embryo survival significantly increased by 1.5% and 1.8%. Number of first quality chicks improved significantly by 3.6%.

DSM Nutritional Products have run a number of field trials around the world, some of which are summarised in Table 1; the overall result is the production of more viable chicks and better fertility. It is worth noting that the male breeders have always received the same supplementation as the female, which may be a contributory factor to better overall fertility.

Conclusion

Canthaxanthin has proved to be an efficient scavenger of free radicals. In recent years, it has become evident that in the cell, not the vitamin E concentration itself, but its association with other natural antioxidants is what determines the efficiency of antioxidant protection.

Experimental evidence indicates that canthaxanthin can also take part in the antioxidative protection of the tissues like spermatozoids or embryo.

This suggests that increased levels of canthaxanthin in the egg yolk would be beneficial for the fertility and the production of more viable chicks. ■

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