

DSM Guidelines for egg yolk pigmentation with CAROPHYLL®

HEALTH • NUTRITION • MATERIALS



CAROPHYLL® - because color matters

Yolk color is one of the main criteria used by the consumer to judge the quality of eggs. Depending on geographical location, culture marketing and tradition, there are specific perceptions in color. However, it is certainly true that consumers in most parts of the world prefer golden-yellow yolks. Eggs are also used in the manufacture of pasta, bakery products, mayonnaise, etc., and they are able to give them a pleasant color.

The carotenoids present in the feed of the laying hen, are responsible for egg yolk color. The most important sources of carotenoids in poultry feed are yellow corn (and derivatives), marigold extracts and nature-identical carotenoids like the ones present in our CAROPHYLL® line of products.

The egg industry and the consumer prefer well colored yolks, and they are right:

A well pigmented yolk always comes from a healthy hen.



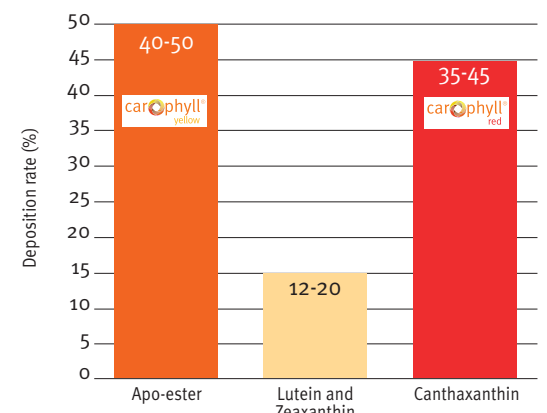
Factors affecting egg yolk pigmenting efficiency

The egg yolk pigmenting efficiency of carotenoids is determined by two main factors: the deposition of the pigment in the egg yolk and its color (wavelength).

Deposition in egg yolk

Deposition of dietary carotenoids in the egg yolk depends on the individual carotenoid molecule (Figure 1). As the content of carotenoids in the feed increases, their concentration in the egg yolk rises in direct proportion.

Figure 1. Egg yolk deposition rates of various dietary carotenoids



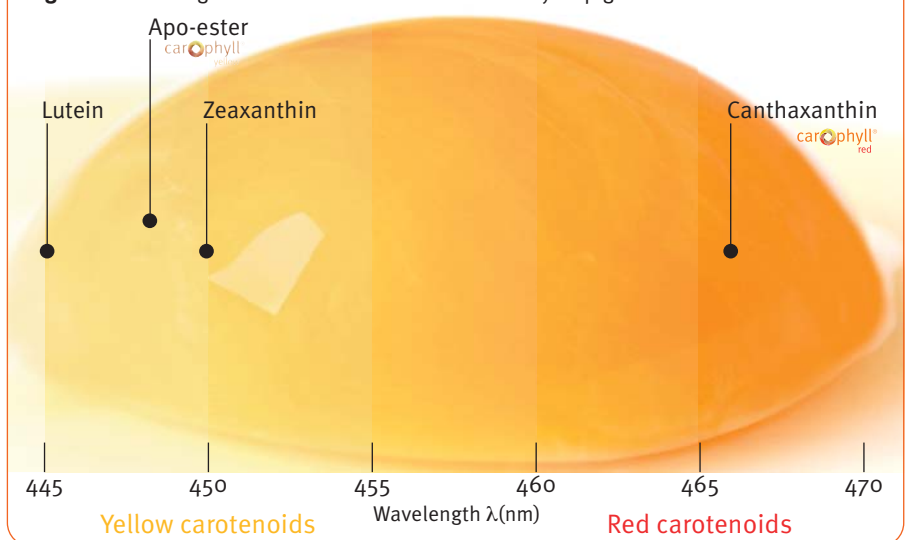
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The color of carotenoids

The wavelengths of the colors of the carotenoids used for egg yolk pigmentation fall between 400 nm and 600 nm within the visible range of the color spectrum. To the human eye, such compounds are yellow to red in color. Lutein, zeaxanthin and apo-ester are yellow carotenoids (wavelength from 445 to 450 nm), whereas canthaxanthin is a red carotenoid (wavelength from 465 to 470 nm).



Figure 2. Wavelengths of various carotenoids used for yolk pigmentation



The principle of egg yolk pigmentation

There are two components of egg yolk pigmentation. The first (referred to as the saturation phase) involves the deposition of yellow carotenoids to create a yellow base corresponding to a DSM Yolk Color Fan score around 7. Such a yellow base is very important for good saturation of the final color. Once the yellow base is established, the addition of the red carotenoid canthaxanthin (CAROPHYLL® red) changes the color hue to a more orange-red color (the second component, or color phase). The dose-related color response to red carotenoids is higher than the response to yellow carotenoids, and the combination of yellow and red carotenoids is therefore more cost effective for egg yolk pigmentation.

Figure 3 shows this principle.

Figure 3. Egg yolk pigmentation phases

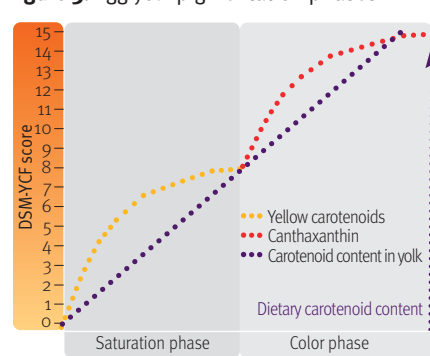


Table 1. Relative pigmenting efficiency of yellow carotenoids

Yellow carotenoids (saturation phase)	Relative pigmenting efficiency
CAROPHYLL® yellow (Apo-ester)	3
Lutein/Zeaxanthin ¹	1

¹ Regardless of the proportion of lutein and zeaxanthin.

Regarding the relative pigmenting efficiencies of the yellow carotenoids, apo-ester (CAROPHYLL® yellow) is more efficient than lutein and zeaxanthin, the main carotenoids in feedstuffs. The very high deposition rate of apo-ester (CAROPHYLL® yellow) makes it the most suitable yellow carotenoid for the saturation phase.

Table 1 below shows the relative pigmenting efficiency of yellow carotenoids (based on deposition rates).

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How to use the DSM Yolk Color Fan?

The DSM Yolk Color Fan provides a simple mean of measuring yolk color. However, attention should be paid to the following factors during the procedure:

- The evaluation should be carried out against a white non reflective surface, in order to eliminate the influence of adjacent colors.
- Use indirect daylight with no strong artificial light. It is important to avoid reflection from the glossy surface of the yolk.
- The blades of the fan should be held immediately above the yolk, viewed vertically from above, the blade numbers facing down and the yolk between the tips of the blade. The reader should always face the side of the blade with no numbers and show the number to the assistant for recording.
- Between each egg the fan should be closed to assure the independency of every measurement
- The evaluation of any experimental series should be carried out by the same trained observer. The series should comprise between four and fifteen eggs (depending on variability) and they should be evaluated individually.
- When finished, please clean the fan and keep it away from direct sources of light.



How to obtain the required DSM Yolk Color Fan (DSM-YCF) score with CAROPHYLL®?

First set the Yolk Color Fan (DSM-YCF) score. If you choose 12/13 most of your eggs will fall between these two scores.

Refer to table 3 and calculate the amount of xanthophyll contained in the ingredients used in the formulation; and to finish, review table 4 to know how much CAROPHYLL® yellow and red is needed to obtain the required DSM-YCF score.

Example: the target DSM-YCF score is 13. The feed contains 15% yellow corn, 2% corn gluten (60%) and 1% DDGS. Table 3 shows that the yellow xanthophyll content of this feed is 6 ppm.

Table 3. Example for calculating the xanthophyll content of a feed

Feed ingredient	Yellow xanthophyll content (ppm)*	Ingredient inclusion rate (%)	Total xanthophylls (ppm)
Yellow corn	14	15	2.1
Corn gluten (60%)	180	2	3.6
DDGS	25	1	0.3
Other ingredients	0	79	0
Total xanthophyll content of feed			6.0

* Xanthophyll content of feedstuffs varies depending on strain differences, harvest, processing and storage conditions.

At this point you can use least cost formulation. Or use Table 5 to fix the required levels of CAROPHYLL® yellow and CAROPHYLL® red.

Least cost formulation

An example of settings for least cost formulation:
To obtain a DSM-YCF score of 13, you need 10.5 ppm of yellow carotenoids (yellow base). Following the example from Table 3, we have to add 4.5 ppm of yellow carotenoids on top of the feed content (10.5-6). When using Apo-ester, we divide this amount by 3 (Table 1), reflecting its higher pigmenting efficacy. Therefore, we have to add 1.5 ppm of Apo-ester (15 ppm of CAROPHYLL® yellow 10%) and 4 ppm of Canthaxanthin (40 ppm of CAROPHYLL® red 10%).

Table 4. Total carotenoids needed for least cost formulation

DSM-YCF score	Yellow carotenoids = lutein+zeaxanthin+3 x apo-ester (ppm)	Canthaxanthin (ppm)
8	7.5	0.5
9	7.5	1.0
10	7.5	1.5
11	7.5	2.0
12	9	3.0
13	10.5	4.0
14	10.5	5.0
15	10.5	5.5



Recommended levels^{1,2} of CAROPHYLL® yellow and CAROPHYLL® red for yolk pigmentation according to the target DSM yolk color fan score

Table 5.

Yellow carotenoids in feedstuffs (ppm)	7/8	8/9	9/10	DSM Yolk Color Fan score				
				10/11	11/12	12/13	13/14	14/15
0-2	20-25 ● 5 ●	20-25 ● 5-10 ●	20-25 ● 10-15 ●	20-25 ● 15-20 ●	25-30 ● 25-30 ●	30-35 ● 35-40 ●	30-35 ● 40-50 ●	30-35 ● 50-55 ●
2-4	15-20 ● 5 ●	15-20 ● 5-10 ●	15-20 ● 10-15 ●	15-20 ● 15-20 ●	20-25 ● 25-30 ●	25-30 ● 35-40 ●	25-30 ● 40-50 ●	25-30 ● 50-55 ●
4-6	10-15 ● 5 ●	10-15 ● 5-10 ●	10-15 ● 10-15 ●	10-15 ● 15-20 ●	15-20 ● 25-30 ●	20-25 ● 35-40 ●	20-25 ● 40-50 ●	20-25 ● 50-55 ●
6-8	5-10 ● 5 ●	5-10 ● 5-10 ●	5-10 ● 10-15 ●	5-10 ● 15-20 ●	10-15 ● 25-30 ●	15-20 ● 35-40 ●	15-20 ● 40-50 ●	15-20 ● 50-55 ●
8-10	5 ●	5-10 ●	10-15 ●	15-20 ●	5-10 ● 25-30 ●	10-15 ● 35-40 ●	10-15 ● 40-50 ●	10-15 ● 50-55 ●
10-15	5 ●	5-10 ●	10-15 ●	15-20 ●	20-25 ●	0-10 ● 30-35 ●	0-15 ● 40-50 ●	5-15 ● 50-55 ●
15+		5 ●	10-15 ●	15-20 ●	20-25 ●	30-35 ●	40-50 ●	50-55 ●

¹ = ppm of CAROPHYLL® yellow 10%. ² = ppm of CAROPHYLL® red 10%. Based on daily feed consumption of 110 g/hen/day. If consumption is lower increase CAROPHYLL® inclusion accordingly. To maintain saturation in boiled eggs an additional 20-40 ppm of CAROPHYLL® yellow is recommended.

Total carotenoids evaluation with iCheck® Egg

iCheck® Egg delivers a fast and accurate method to evaluate total carotenoids as β-carotene equivalents in yolk. The relationship between color and carotenoid concentrations in the yolk is not linear. At high carotenoid inclusion levels, the use of the color fan or colorimeters is not effective to estimate their concentration in the yolk. iCheck® Egg is the perfect alternative to HPLC. It is accurate, portable, mobile and economical. Especially suited for liquid whole eggs, high color liquid yolks and for whole and yolk powder.

Contact your DSM sales representative if you would like to benefit from the iCheck® Egg device.



CAROPHYLL® products - consistent egg yolk pigmentation

Many years of experience in carotenoid chemistry have given DSM the expertise to manufacture CAROPHYLL® products of exceptional quality.

CAROPHYLL® yellow 10% and CAROPHYLL® red 10% are free-flowing, granulated carotenoid products. They consist of small beadlets in which the carotenoid is finely distributed in a starch-encapsulated plant and carbohydrate matrix to which antioxidants have been added making CAROPHYLL® animal-free products.

The special manufacturing process, known as 'spraydried coating', protects the carotenoids against oxidation and gives them high stability, optimal distribution, outstanding mixing properties and very good absorption characteristics.

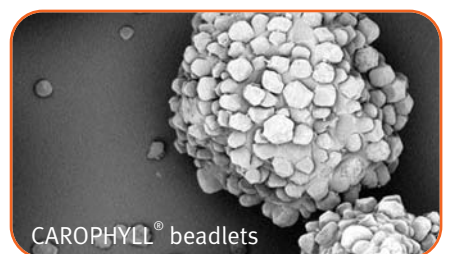


Table 2. Specifications of CAROPHYLL® yellow 10% and CAROPHYLL® red 10%

	CAROPHYLL® yellow 10%	CAROPHYLL® red 10%
Appearance	Brown-red, free flowing particles	Violet-red to red-violet, free flowing particles
Fineness (U.S. standard sieves)	100% through No. 20 Min. 90% through No. 40 Max. 20% through No. 100	100% through No. 20 Min. 90% through No. 40 Max. 30% through No. 100
Min content	10% Apo-ester	10% Canthaxanthin