

Egg yolk pigmentation guidelines

ANIMAL NUTRITION AND HEALTH



DSM

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A golden yolk can only come from a healthy hen

To present an attractive golden yolk, carotenoids have to:

- Be absorbed in sufficient quantities
- Absorbed (via a healthy gut)
- Not be used as antioxidants (low immunological challenges)
- Not be used as vitamin precursor (good vitamin status).

Therefore the hen, the environment and the feed have to work in concord to deliver an attractively pigmented yolk. In nature, the male birds with the best coloration will attract the females. This makes sense, because only the healthier individuals will be able to obtain appealing feathers. The same goes for the females: the healthier hens will have more carotenoids for their eggs. So, in order to have a golden yolk, you need a good-quality feed, the correct husbandry practices and – more importantly – a healthy hen.



Factors affecting egg yolk pigmenting efficiency

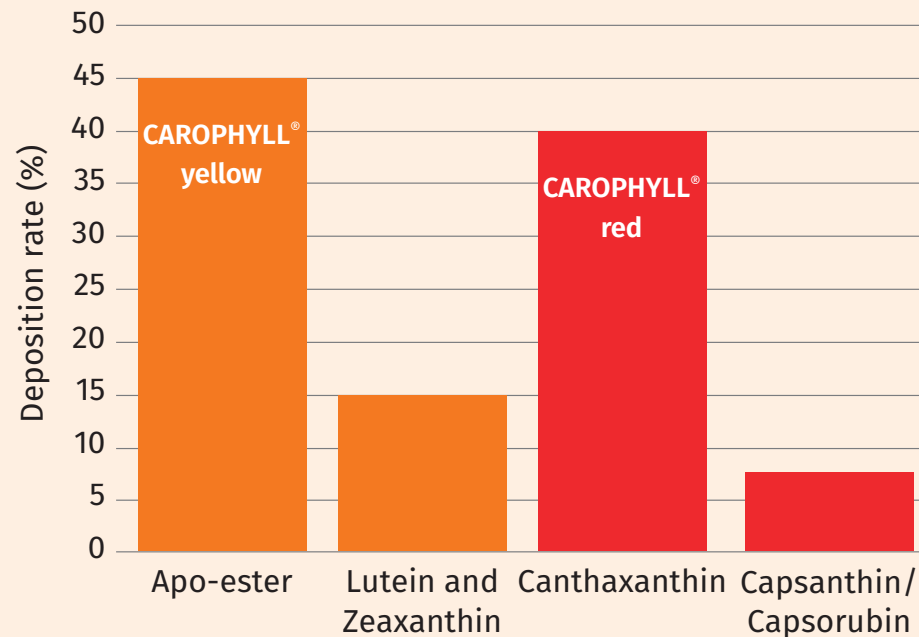
The egg yolk pigmenting efficiency of carotenoids is determined by two main factors: egg yolk deposition rate and carotenoid color (wavelength).

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 carotenoids



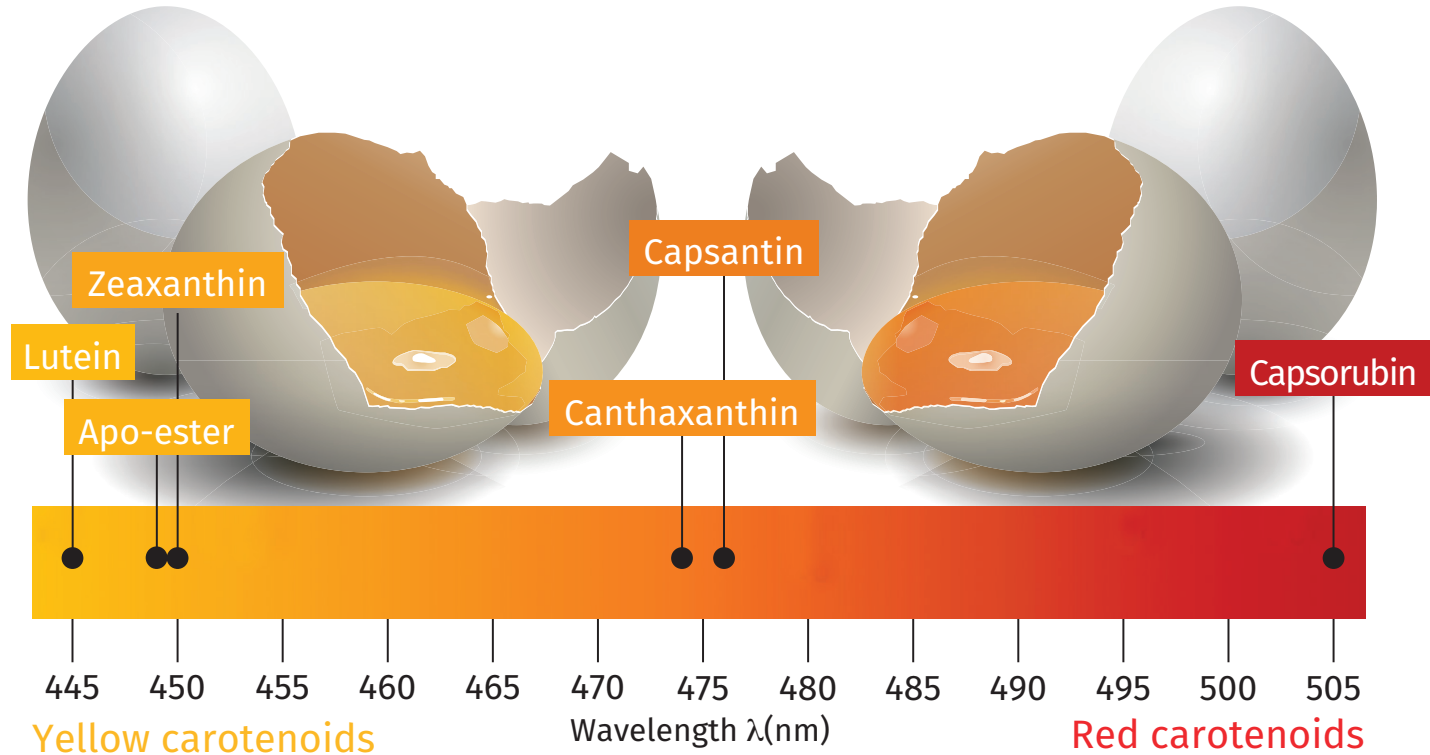
Factors affecting egg yolk pigmenting efficiency

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). However, a red carotenoid with a redder hue, will require higher inclusion rate, if its deposition rate is low, like in the case of the Capsanthin/ Capsorubin combination found in paprika.

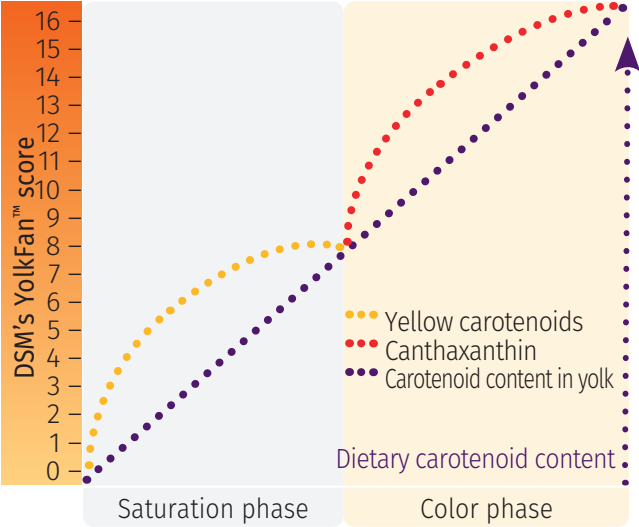
Figure 2. Wavelengths of various carotenoids used for yolk pigmentation.



Factors affecting egg yolk pigmenting efficiency

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's YolkFan™** 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 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 illustrates this principle.

Figure 3. Egg yolk pigmentation phases



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).

Table 1. Relative pigmenting efficiency of yellow carotenoids

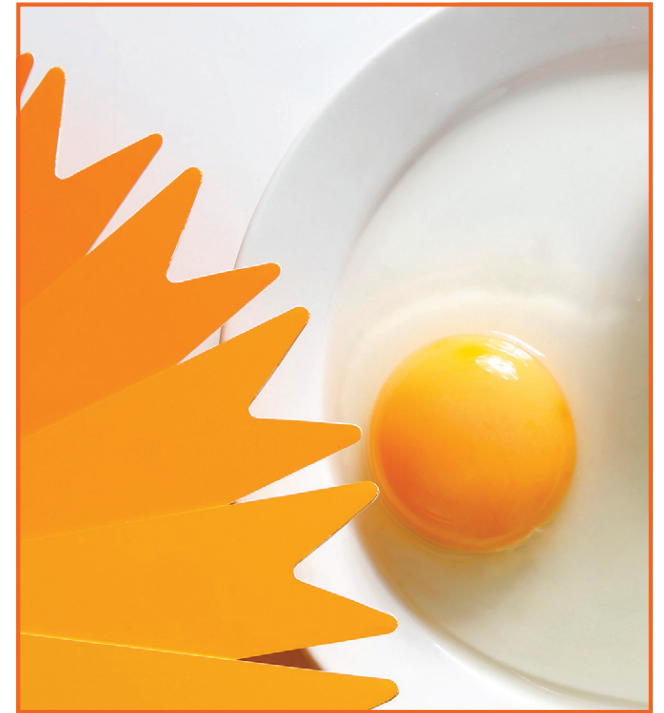
Yellow carotenoids (saturation phase)	Relative pigmenting efficiency
CAROPHYLL® yellow (Apo-ester)	3
Lutein/Zeaxanthin ¹	1

¹ Regardless of the proportion of lutein and zeaxanthin.

How to use the DSM's YolkFan™

The DSM's YolkFan™ provides a simple means of measuring yolk color. However, attention should be paid to the following factors during the procedure:

1. The evaluation should be carried out against a white non-reflective surface, in order to eliminate the influence of adjacent colors.
2. Use indirect daylight with no strong artificial light. It is important to avoid reflection from the glossy surface of the yolk.
3. The blades of the fan should be held immediately above the yolk, viewed vertically from above, with 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 ensure the independency of every measurement.
4. The evaluation of any experimental series should be carried out by the same trained observer. The series should comprise between 4 and 15 eggs (depending on variability), and they should be evaluated individually.
5. When finished, please clean the fan and keep it away from direct sources of light.



How to obtain the required DSM's YolkFan™ score with CAROPHYLL®

First set the **DSM's YolkFan™** 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's YolkFan™** score.

Example: the target **DSM's YolkFan™** 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.

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

Table 2. Example for calculating the xanthophyll content of feed

		Xanthophyll content, ppm		Ingredient	
Feed ingredient	Range*	Analyzed (example)	Inclusion rate (%)	Xanthophylls contribution, ppm	
Yellow corn	5-20	14	15	2.1	
Corn gluten (60%)	150-400	180	2	3.6	
DDGS**	10-50	25	1	0.3	
Other ingredients	0	0	79	0.0	
Total xanthophyll content of feed				6.0	

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

** Dried distillers grain with solubles.

Formulation

An example of a possible least cost formulation:

To obtain a **DSM's YolkFan™** 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 3. Total carotenoids needed for least cost formulation

DSM's YolkFan™ 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	9.0	3.0
13	10.5	4.0
14	10.5	5.0
15	10.5	5.5
16	12	8.0

Recommended levels

Table 4. Recommended levels^{1,2} of CAROPHYLL® yellow and CAROPHYLL® red for yolk pigmentation according to the target DSM's YolkFan™ score

Yellow carotenoid in feedstuffs (ppm)		DSM's YolkFan™ Target score								
		7/8	8/9	9/10	10/11	11/12	12/13	13/14	14/15	15/16
0-2	●	20-25	20-25	20-25	20-25	25-30	30-35	30-35	30-35	35-40
	●	5	5-10	10-15	15-20	25-30	35-40	40-50	50-55	75-80
2-4	●	15-20	15-20	15-20	15-20	20-25	25-30	25-30	25-30	35-40
	●	5	5-10	10-15	15-20	25-30	35-40	40-50	50-55	75-80
4-6	●	10-15	10-15	10-15	10-15	15-20	20-25	20-25	20-25	30-35
	●	5	5-10	10-15	15-20	25-30	35-40	40-50	50-55	75-80
6-8	●	5-10	5-10	5-10	5-10	10-15	15-20	15-20	15-20	25-30
	●	5	5-10	10-15	15-20	25-30	35-40	40-50	50-55	75-80
8-10	●					5-10	10-15	10-15	10-15	20-25
	●	5	5-10	10-15	15-20	25-30	35-40	40-50	50-55	75-80
10-15	●						0-10	0-15	5-15	15-20
	●	5	5-10	10-15	15-20	25-30	35-40	40-50	50-55	75-80
15+	●									10-15
	●	5	5-10	10-15	15-20	25-30	35-40	40-50	50-55	75-80

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.

The classic YolkFan™ and the new digital YolkFan™ Pro

To succeed in any yolk pigmentation program, it is important to measure. For more than five decades, the **DSM's YolkFan™** has been the standard on yolk pigmentation measuring technology. It went from a few blades back in the sixties, to the newer version with 16 blades launched in 2016. By customers request, the YolkFan™ evolved in to the digital YolkFan™ Pro allowing data handling capabilities, multi-device monitoring and measurement of other poultry products like skin or tarsos. The device is connected to any smartphone via a user friendly App that is available in the two most common operating systems and allows small size, portability and most importantly: objective measurement with no light, observer bias or interference. The

digital era in poultry pigmentation technology.

Of course, the classic YolkFan™ is still available as a practical resource for a quick color check.



CAROPHYLL® products – consistent egg yolk color

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.

The special manufacturing process used, protects the carotenoids against oxidation and gives them high stability, water dispersibility, outstanding mixing properties, and very good absorption characteristics.

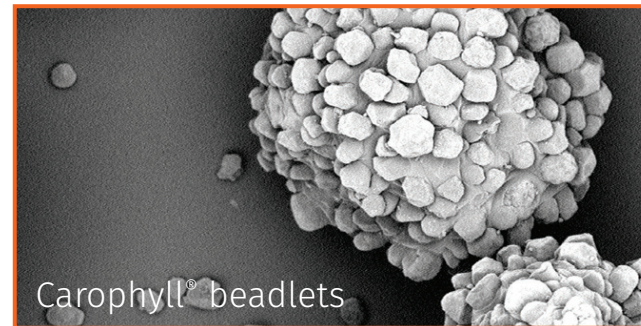


Table 5. Specifications of CAROPHYLL® yellow 10% and CAROPHYLL® red 10%

	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

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