Opportunities for use of Carotenoids in egg production

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Carotenoids in nature

Carotenoids are very common molecules in nature
They are synthesised by:

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Algae</th>
<th>Fungi</th>
<th>Plants</th>
</tr>
</thead>
</table>

Nature produces 100 Million MT of Carotenoids per year

3 tons per second!
Why include carotenoids in laying hens’ diets?

- Pro-vitamin A and antioxidant
- Hens are incapable of synthesising carotenoids - provided through diet, like vitamins
- Inclusion of carotenoids improves vitelline membrane integrity
- Ensure a healthy consistency
- To improve the colour of egg yolks
- Other benefits: anti carcinogenic properties, anti oxidant effect
Deposition rate of various carotenoids in egg yolk

From Bauernfeind, 1981
Extracted production

100 tons fresh flowers
10 tons dried pellets

Silage, drying, pelleting

13-20 kg xanthophylls

Extraction with solvents and saponification

1 ton oleoresins

Concentration

Coating

Lutein

Zeaxanthin
Nature identical production

Spray drying

Coating

Formulation

Concentration

100kg/ton
CAROPHYLL® Red and Yellow 10%

Cross section through beadlet

Vegetable matrix: plant-based coating material (patent EP 0 565 989) that replaces animal gelatine used in the previous forms of CAROPHYLL® Red & CAROPHYLL® Yellow

GMO STATUS: free

Maize starch

Inner phase (0.2 - 0.4 mm) canthaxanthin or apo-ester, antioxidant

0.30 mm
Depending on the supplier, there are considerable differences in the product forms.
Better homogeneity of the colour with nature identical carotenoids

<table>
<thead>
<tr>
<th>Apo-ester</th>
<th>BCE ppm Liquid eggs</th>
<th>Variation %</th>
<th>Xantho from Tagetes</th>
<th>BCE ppm liquid eggs</th>
<th>Variation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 ppm</td>
<td>16.6</td>
<td>7.8</td>
<td>15 ppm</td>
<td>14</td>
<td>12.8</td>
</tr>
<tr>
<td>10 ppm</td>
<td>19.8</td>
<td>2.5</td>
<td>30 ppm</td>
<td>18.7</td>
<td>7</td>
</tr>
<tr>
<td>20 ppm</td>
<td>31</td>
<td>6.4</td>
<td>60 ppm</td>
<td>28.3</td>
<td>17.7</td>
</tr>
</tbody>
</table>

Variation of the colour is higher

Steinberg et al, 2000
Canthaxanthin can support a better stable colour

Cook the egg in boiling water for 12 minutes.

**CAROPHYLL Red**  Paprika Extract

**Same egg yolk color: DYCF 14**

- Corn: 60%
- CR: 75ppm
- CY: 25ppm

- Corn: 60%
- CGM: 4%
- Paprika: 2.5kg/MT feed
Bioavailability - nature identical
Geometrical isomers

*trans*-carotenoids are more effective

*trans*-Carotenoids (E)
- Redder hue
- Higher stability
- Slightly higher pigmenting efficiency

*cis*-Carotenoids (Z)
- Yellower hue
- Poorer stability
- Slightly lower pigmenting efficiency

Torrissen OJ, 2000; Hencken K, 1992
Safety of nature identical carotenoids

- Re-evaluation of all feed carotenoids is ongoing in the EU

- The safety of canthaxanthin has been assessed several times in the last 15 years, making it the most documented carotenoid for poultry application (EFSA, 2010).
Safety of extracted carotenoids

• 23 notifications via RASFF since 2002 all due to dioxins

• 6 cases 2011/2012, all but one distributed further into the market

• 2 cases of dioxin contaminated products being distributed to Denmark in the past year
Life Cycle Assessment

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Nature-Identical</th>
<th>Natural extract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per 100,000 eggs DYCF 12</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>230 MJ</td>
<td>190 MJ</td>
</tr>
<tr>
<td>Emissions</td>
<td>12kg CO2 eq</td>
<td>12kg CO2 eq</td>
</tr>
<tr>
<td>Acidification potential</td>
<td>30g SO2 eq</td>
<td>30g SO2 eq</td>
</tr>
<tr>
<td>Ozone depletion potential</td>
<td>0.002mg CFC eq</td>
<td>0.005 mg CFC eq</td>
</tr>
<tr>
<td>Land use</td>
<td>0 m²</td>
<td>0 m²</td>
</tr>
<tr>
<td>Critical water volume</td>
<td>2000 m³</td>
<td>35000 m³</td>
</tr>
<tr>
<td>Risk potential*</td>
<td>6 units</td>
<td>7 units</td>
</tr>
<tr>
<td>Toxicity potential**</td>
<td>1.5 units</td>
<td>1 unit</td>
</tr>
</tbody>
</table>

* Risk potential calculated different risks depending on reaction temperatures, pressures, inflammable materials, etc. as well as accident statistics from different industry sectors in different countries. Transportation risks were estimated where longer transportation distances resulted in higher risk evaluations.

**Toxicity potential was determined using an assessment method based on the R-phrases of the Hazardous Substances Regulation Act (GefStoffV) and based on units calculated in a matrix with weighted points based on severity according to their toxicity potential.
Bodies who convert from natural extracted carotenoids to nature-identical carotenoids

1. The Danish Egg Industry 2012
2. The Norwegian Egg Industry 2012
3. The retailer Delhaize Belgium 2012
4. The retailer Colruyt Belgium 2011
5. The retailer Carrefour France 2010
6. The food company Kewpie Japan 2009
Conclusions

• LCA studies reveal that nature identical carotenoids production and use are the most sustainable compared to other forms.

• Carophyll® has higher levels of bioavailability (trans-carotenoids).

• The formulation weakness of the other carotenoid sources is reflected in lower stability values throughout the feed processing chain.

• The superior formulation characteristics of Carophyll® are reflected in stability and performance as indicated by deposition rates in eggs.

• Carophyll® have a proven track record of a high level of safety for the food chain.