Supplement: Why Colour Foods?
Colouring Food Products with Roche Carotenoids

Nature is arrayed in the full spectrum of colours. A life without colour would be impossible to imagine.

Man lives with colour, and colour is part of his daily life. This applies also to his eating habits, and it is legitimate to say that man eats not only with his mouth but with his eyes as well. Natural, living colours stimulate the appetite and digestion, and increase the pleasure of eating. It is no accident that saffron, extracts of berries, and other naturally occurring food colours have for centuries been used all over the world for preparing food.

Today, the food industry is the kitchen of the world. It has revolutionised nutrition. Never before have standards of purity, stability, and physiological harmlessness been as high as they are today. New raw materials and new methods of refining and preserving, however, often alter the natural appearance of fresh foods. The natural colours of food must be restored to them if they are to be not merely nutritious but appetising as well.

The carrot, archetype and symbol of appetisingly coloured and nutritious food, was the starting point of a research programme that has lasted more than a century, and it is hence logical that it should have given its name to the carotenoids.

The carotenoids are the pigments responsible for the colours of a summer meadow, the plumage of birds, ripe berries, and the autumn harvest. The appetising colours of butter, eggs, carrots, green vegetables, tomatoes, lobsters, and apples are but a few examples of the natural beauty of foods containing carotenoids.

Carotenoids are, in other words, the colours naturally present in food. Roche carotenoids are food colours borrowed directly from nature.

The Properties of Carotenoids

(a) Natural occurrence

The carotenoids are widely distributed in nature. They are to be found in egg yolk, tomatoes, fungi, all green leaves, fruits, and flowers. They also occur in crustaceans, certain fish species, feathers and insects.

(b) Colour Intensity

The carotenoids are very powerful colouring agents: only minute quantities are needed to give foods an attractive appearance. For example, as little as 3 to 5 grams of β-carotene is all that is required to give one tonne of margarine its appetising golden colours.

(c) Harmlessness

β-Carotene and other carotenoids have been regularly eaten by man in his food for thousands of years.

(d) Purity

Carotenoids isolated from natural products vary widely in quality and colouring power. Carotenoids obtained from chemical synthesis, by contrast, being of the highest purity and of unvarying quality, are therefore ideally suited for the natural reliable, and safe colouring of foods.

(e) Stability

Foods whose colour is standardised with carotenoids retain their appearance for long periods. In fruit juice beverages to which ascorbic acid has been added whether to protect the flavour or for its vitamin C value the carotenoids are completely stable, unlike most artificial food dyes. They also withstand the action of direct sunlight.

(f) Biological activity

Some carotenoids can be converted into vitamin A in the human body. The conversion factor of β-carotene to vitamin A is 6:1 (6 mg β-carotene corresponds to 1 mg vitamin A as retinol). Some other carotenoids such as apocarotenal have a 50% lower activity compared to β-carotene, and certain types, such as lycopene, have no vitamin A activity. However, all conversion factors are compromises, since the actual conversion depends on the vitamin A status of the body.

A very promising aspects of carotenoids is their ability in the human body to prevent damage caused by free radicals. There is much epidemiological evidence that carotenoids may help in the prevention of certain degenerative diseases. Experts recommend diets rich in carotenoids. β-Carotene plays a key role in the antioxidant system of the human body.

The Chemistry of the Carotenoids

In the Vegetable kingdom, the carotenoids, which are fat-soluble, occur in a very finely divided state, and in this form they may also be the colouring

Chemical Name	Molecular formula	Molecular weight	Melting point (°C)	Absorption maxima (in cyclohexane)	Solubility
β-Carotene	$C_{40}H_{56}$	536.89	176-182	At approx. 456 and 485 nm	Water: insoluble Ethanol: practically insoluble Vegetable oils: slightly soluble (to approx. 0.1%)
β-Apo-8'carotenal	$C_{30}H_{40}O$	416.65	136-140	At approx. 461 and 488 nm	Water: insoluble Ethanol: slightly soluble Vegetable oils: slightly soluble (to approx. 1.5%)
Ethyl β-Apo-8'-carotenoate	$C_{32}H_{44}O_2$	460.70	134-138	At approx. 449 and 475 nm	Water: Insoluble Ethanol: very slightly soluble vegetable oils: slightly soluble (to approx. 1%)
Canthanxanthin	$C_{40}H_{52}O_2$	564.86	approx. 210 (decomp)	At approx. 470nm	Water: insoluble Ethanol: practically insoluble Vegetable oils: very slightly soluble) to approx. 0.005%)
Lycopene	$C_{40}H_{56}$	536.85	170-173	At approx. 471 and 504 nm	Water: insoluble Ethanol: practically insoluble Vegetable oils: Slightly soluble (to approx. 1%)

principles of aqueous systems (e.g. tomatoes, carrots, oranges).

In plants, the carotenoids are probably bound to proteins and perhaps also to carbohydrates.

In the purified, crystalline state, carotenoids are violet-brown to brick-red crystalline powders, which dissolve in oil or organic solvents to give a yellow to red colour depending on the concentration.

Fat Based Products

Suspensions of apocarotenal, β-carotene and apocarotenoic ester have been developed especially for the food industry; they consist of micronized crystals of these carotenoids finely dispersed in vegetable oil, a form most suitable for rapid and uniform processing.

Some major application are described on the next pages.

Applications

Carotenoid suspension are widely used in the fat-and milk-processing industries for colouring or for standardising the colour of margarine, edible oils, butter, etc.; they also find applications in other products such as beverages, salad creams and dressings, popcorn, and canned soups.

Stability and Storage

Carotenoid suspensions and solutions are stable for the guaranteed shelf life, when stored in the original unopened package in a cool, dry place. Partly used packages should be carefully re-sealed, stored in a refrigerator and used up within a short time.

Application Guide for Fat-based Products

Margarine

A vegetable oil of minimum peroxide value should be selected as a solvent for the preparation of the stock solution.

Heat the oil to a temperature between 60-85° C (140-185 °F), and add the carotenoid suspension. Agitate until the solution gets clear.

The oil should not exceed 85° C (185° F) due to partial isomerization of the carotenoid crystals with some loss of colour and/or biological activity. Add a part of this stock solution, which corresponds to 3-6 ppm pure carotenoids, during the oil blending process to the final food product to obtain the typical butter colour in the margarine.

After mixing the oil-soluble ingredients thoroughly, slowly add water phase to the oil phase under agitation to form an emulsion.

The emulsion may be pasteurised at 73° C (164 °F) for 16s. before being chilled in the mutator.

Popcorn

Popcorn can be coloured by popping the corn in oil and/or shortening coloured with β-carotene, or by spraying the popped corn with vegetable oil containing β-carotene.

When using β-carotene, the colour of the popping oil can be varied from a light yellow to a golden yellow. The β-carotene is stirred into the popping oil. Heating the oil to 40°C (104°F) will speed up dissolution. Typical use levels correspond to 70 – 130 ppm pure carotenoid.

Ice Cream

For the coloration of ice cream it is recommended to prepare a 1% (W/W) carotenoid stock solution using a sunflower oil with a minimum peroxide value as a solvent.

Heat the oil to 85° C (185° F) and add the carotenoid suspension under stirring until the dispersion becomes clear.

Add the stock solution to the cream under stirring to achieve a homogenous distribution.

Vanilla/lemon colorations in the ice cream are obtained with 5 to 10 ppm-carotene as β-carotene 30% FS.

Raspberry/strawberry coloration's with 5 to 10 ppm apocarotenal as Apocarotenal 20% S. Mix all dry ingredients thoroughly and dissolve the mix in the coloured cream /milk blend under stirring. Heat the ice cream mix to 60°C (140°F) before the addition of the glucose syrup.

Homogenise at P1 200 bar; P2 50 bar and pasteurise at 80°C (176 °F) for 15 s.

Add the flavour after the mix has cooled down to 5°C (41 °F) and leave to stand for at least 4 hours before freezing.

Processed Cheese

There are two product forms specifically developed to obtain a wide range of shades suitable for process cheese: Carotenal Solution No. 2 and Carotenal Solution No. 73. They eliminate the need for blending colours by simple adjustment of the concentration.

Since both product forms are true solutions, the required amount can be added directly to the ground cheese in mixing or processing equipment as usual.

A good colour can be obtained by adding 30 to 45 ml (2.5-3.5 fl oz) of solution to 100 kg (500 lb.) of processed cheese, which corresponds to 6 to 8 PPM pure carotenoid.

Salad Dressings

Carorenal Solution No. 2 and Carotenal solution No. 73 are particularly suited to produce salad dressings which are bright

Table 2. Roche Carotenoid product forms for oil-and fat-based products

	β-Carotene 30% FS	β-Carotene 22% HSS	Carotenal Solution No.2	Carotenal solution No.73	Apocarotenal 20% S	Apocarotenal Ester 20% S
Code	04 2723 3	04 6604 2	04 8277 7	04 8054 1	04 8093 2	04 3704 2
Shelf life (months)	36	12	24	24	36	12
Margarine	✓				✓	
Vegetable oils	✓				✓	
Cheese			✓	✓		
Butter, creams	✓					✓
Ice creams	✓					
Salad creams, dressings	✓			✓	✓	
Sauces	✓				✓	
Popcorn		✓				
Snacks	✓	✓				
Other Fields of application	Beverages	-	Dairy, pastry, dressings, whipped margarine	Dairy, pastry, whipped margarine	Beverages	-

and appealing. The solutions should be blended with at least 5% of the oil from the batch before being added. No other manufacturing changes are necessary. The amount required varies significantly according to the desired colour shade, but could be in the range of 60-80 ml (30-40 ml) of solution per kg (lb.) dressing.

Water based Products

These preparations are free flowing powders consisting of minute spherical particles. Because of the special production processes used, the preparation can be dispersed in water, thus allowing a considerably wider range of applications than the suspensions.

Applications

The water-dispersible preparations can be used singly or in combination, depending on the desired end colour, for colouring or for standardising the colour of foods. Some important applications are described.

(a) Stability and storage

The contents of unopened packages undergo virtually no change for several months when stored in a cool place. Once they have been opened, packages should be carefully re-sealed and stored in a cool, dry place, after which the colouring power of the preparation will be largely preserved for a few weeks. If they are not stored under proper conditions, the preparations will suffer as regards colour intensity and dispensability in water.

Assay

Special methods of analysis for the determination of carotenoids after additions to foods can be supplied on request.

Mode of Use

The preparations should be stored in a cool, dry place. Before they are opened, the containers should be kept for at least 12 hours at room temperature to avoid contamination with condensation water. The method to prepare a stock solution are described in this supplement but can be given on request. As a general rule, it should be prepared only shortly before it is required and should be fully used as soon as possible.

Application Guide for Water Based Products

Beverages

For the coloration of beverages, β-Carotene 5% EM can be added directly to the other liquid ingredients.

When using the carotenoid powders, it is recommended to prepare a 1-10% (W/W) stock solution.

Prepare this stock solution by slowly adding the carotenoid powder to demineralized water under stirring.

The carotenoid suspensions should be dissolved in a vegetable oil in combination with a weighting agent such as ester gum or SAIB (sucrose diacetate hexaisobutyrate) to adjust the density of the oily phase to that of the aqueous phase, to prevent the formation of a neck ring in the final product.

Add the stock solution slowly to the liquid ingredient or concentrate blend and mix thoroughly without incorporation of air, homogenise at P1 150 bar; P2 50 bar and pasteurise at 85 °C (185 °F) for 15 s. To obtain yellow to orange shades in the final beverage, a quantity of the stock solution is added, corresponding to 3 to 8 ppm β-carotene as β-Carotene 7% CWS or β-Carotene 10% CWS.

Orange to red coloration's can be obtained with 4 -10 ppm carotenoid as Apocarotenal 10% WS/N or Canthaxathin 10% CWS/N Ascorbic acid should be added as an oxidant, corresponding to 50-100 ppm in the final beverage.

Dairy Products

For the coloration of dairy products it is recommended to prepare a 1 to 10% stock solution by pre-dissolving the carotenoid form in milk before use.

To prepare a probiotic milk drink, heat the milk to 40 °C (104 °F) before adding the dry ingredients, and carotenoid stock solution under stirring.

Then heat this mix to 70°C (158°F) to dissolve all ingredients, and homogenised in a high-pressure homogeniser (P1 200 bar; P2 50 bar).

Directly after homogenisation, pasteurise the mix at 85°C (185°F) for 15 s. Cool the mix to 45°C (113°F) before adding the *Lb. acidophilus* culture and incubate at 45 °C (113°F) for approximately 21 h until a pH of 4.2 is reached.

Add the flavour under stirring, cool to 25 °C (77°F) and homogenise at 30 bar.

Finally cool the milk drink to 10°C (50°F) and fill into bottles before storing at 4 °C (39 °F).

Vanilla or orange shades in the final milk drink can be obtained with 5-10 ppm β-carotene as β-Carotene 1% CWS, β-Carotene 5% EM, β-Carotene 7% CWS or

Table 3. Roche Carotenoid product forms for water-based products

	β-Carotene 10% CWS	β-Carotene 7% CWS	β-Carotene 1% CWS	β-Carotene 5% EM	pocarotenal 0% WS/N	pocarotenal % CWS	Canthaxanthin 10% CWS/N	Canthaxanthin 10% RVI	Canthaxanthin 1% CWS/N
Code	04 3425	04 8228 5	04 3452 3	04 2729 2	04 8737 6	04 3462 0	04 8690 6	04 3444 2	04 8795 3
Shelf life (months)	36	18	30	18	33	30	33	33	30
Beverages	✓	✓		✓	✓		✓		
Instant Products			✓			✓			✓
Dairy products	✓	✓		✓					
Confectionery	✓	✓		✓	✓		✓	✓	
Ice creams & water ice	✓	✓		✓					
Soups	✓				✓		✓		✓
Sauces	✓			✓	✓		✓		
Bakery	✓	✓		✓					
Cereals	✓								
Meat products							✓	✓	
Other Fields of application	-	sauces	Beverages, puddings, dairy confectionery, bakery	-	-	Beverages, puddings, dairy cenfectionery, bakery	Dairy	Dairy	Dairy

β-Carotene 10% CWS.

Orange to orange-red colorations can be obtained with 7 to 10 ppm carotenoid as Apocarotenal 1% CWS and 10% WS/N or Canthaxanthin 1% CWS/N and 10% CWS/N.

Instant Products

The carotenoid forms β-Carotene1% CWS, Apocarotenal 1% CWS and Canthaxanthin 1% CWS/N are especially developed for use in instant products, for example beverage, pudding and soup powders.

These carotenoid forms can be blended directly with the other dry ingredients.

Yellow to yellow/orange shades in the diluted product are obtained with 4-8 ppm β-Carotene as β-Carotene 1% CWS.

Orange to orange-red shades are obtained with 6-10 ppm apocarotenal as Apocarotenal 1% CWS.

Orange-red to red colorations with 10-15 ppm canthaxanthin as Canthaxanthin 1% CWS/N.

Confectionery

All Roche water-dispersed carotenoid forms are suitable for use in confectionery products. Roche carotenoid suspensions should be used in soft chewy sweets because of the fat content.

The recommended procedure is to prepare a 1-10% carotenoid stock solution in demineralised water before use.

For the preparation of hard-boiled candies, mix the glucose syrup, sugar and water together well and heat to 140°C (284 °F) in a vacuum steam cooker (vacuum = 680 mm Hg). Pour the hot mixture onto an oiled marble slab. When the mixture has cooled down to about 120 °C (248 °F), add the citric acid, flavour and carotenoid stock solution. Allow the temperature to drop to about 75 °C (167°F) under constant folding before feeding through the drop-roller.

A good colour match for lemon- or orange-flavoured candies can be achieved with 5 to20 ppm β-carotene, for apricot flavoured candies with 10 ppm β-carotene.

10-20 ppm carotenoid as Apocarotenal 10% WS/N or Canthaxanthin 10% CWS/N is needed to match the strawberry and raspberry colour flavour profiles.

Legislation on Food Colours

Roche Carotenoids for Use in Food products

β-Carotene 30% FS

This fluid suspension is a brownish red to reddish-brown viscous oil containing micronised crystals of β-carotene dispersed in corn oil.

dl-α-Tocopherol is added as an antioxidant. The suspension remains liquid at 0 °C.

Solubility

β-Carotene 30% FS is slightly soluble in oils and fats, yielding yellow to orange colorations

β-Carotene 22% HSS

This heat-soluble suspension is a brick-red oil containing micronized crystals of β-carotene dispersed in corn oil.

dl-α-Tocopherol, ascorbyl palmitate and citric acid are added as preservatives

Solubility

β-Carotene 22% HSS is slightly soluble in oils and fats, yielding yellow colorations.

β-Carotene 10% CWS

This cold-water-soluble (beadlet) form is a red-brown, fine granular powder. The individual particles contain β-Carotene finely dispersed in starch-coated matrix of gelatin, sucrose and maize (corn) oil.

dl-α-Tocopherol and ascorbyl palmitate are added as antioxidants.

Dispersibility

β-Carotene 10% CWS is dispersible in cold water, yielding yellow to orange colorations.

β-Carotene 7% CWS

This cold-water-soluble (spray-dried) form is a fine powder of reddish-brown hue. The individual particles contain a finely dispersed oily solution of β-Carotene in a matrix of gelatin*, sucrose, maltodextrin and maize (corn) oil.

dl-α-Tocopherol and ascorbyl palmitate are added as antioxidants, silicon dioxide as a processing aid.

Dispersibility

β-Carotene 7% CWS is dispersed in water, yielding a bright yellow colour.

β-Carotene 1% CWS

This cold-water-soluble (spray-dried) form is a fine powder of orange hue. The individual particles contain a finely dispersed oily solution of β-carotene in a matric of acacia, sucrose, maltodextrin and soya oil.

dl-α-Tocopherol and sodium ascorbate are added as antioxidants.

Dispersibility

β-Carotene 1% CWS is dispersed in water, yielding a yellow colour.

β-Carotene 5% EM

This emulsion is a red to orange-brown liquid with a specific gravity (20 °C) of approx. 1.15 lt contains β-carotene dissolved in a fractioned coconut oil, which is finely emulsified in a sugar syrup with a sugar ester as an emulsifier.

dl-α-Tocopherol is added as an antioxidant, pectin as a stabiliser.

Dispersibility

β-Carotene 5% EM is dispersible in water at any ratio, yielding a yellow coloration.

Apocarotenal 20% S

This suspension is a dark brown, oily liquid containing micronized crystals of apocarotenal dispersed in corn oil.

dl-α-Tocopherol is added as an antioxidant.

Solubility

Apocarotenal 20% S is slightly soluble in oils and fats, yielding yellow to yellow-orange colorations.

Carotenal solution No. 2

This solution is a dark red oil containing 2% apocarotenal compounded with di-β-tocopheral as a stabiliser and fractionated triglycerides of coconut origin.

Solubility

Carotenal Solution No. 2 is slightly soluble in oils and fats, yielding yellow to orange-red colorations.

Carotenal Solution No. 73

This solution is a dark red oil containing 1.4% apocarotenal and 0.6% β-Carotene compounded with dl-α-tocopherol as a stabiliser and fractioned triglycerides of coconut origin.

Solubility

Carotenal Solution No. 73 is slightly soluble in oils and fats, yielding yellow to orange-red colorations.

Apocarotenal 10% WS/N

This water-soluble (beadlet) form is a violet-brown fine granular powder. The individual particles contain apocarotenal finely dispersed in a starch-coated matrix of gelatin*, sucrose and maize (corn) oil. dl-α-Tocopherol and ascorbyl palmitate are added as antioxidants.

Dispersibility

Apocarotenal 10% WS/N is dispersible in water at a minimum temperature of 25 °C, yielding orange-red to red colorations.

Apocarotenal 1% CWS

This cold-water-soluble (spray-dried) form is a fine orange powder. The individual particles contain a finely dispersed oily solution of apocarotenal in a matrix of acacia, carrageenan, sucrose and maltodextrin.

dl-α-Tocopheral and sodium ascorbate are added as antioxidants.

Dispersibility

Apocarotenal 1% CWS is dispersible in water, yielding an orange coloration.

Apocarotenoic Ester 20% S

This suspension is a red-brown, viscous oil containing micronised crystals of apocarotenoic acid ethyl ester dispersed in maize (corn) oil.
dl-α-Tocopherol is added as an antioxidant.

Solubility

Apocarotenoic Ester 20% Suspension is slightly soluble in oils and fats, yielding yellow to yellow-orange colorations.

Canthanxanthin 10% CWS/N

This sold-water-soluble (beadlet) form is a violet-brown, fine granular powder. The individual particles contain canthaxanthin finely dispersed in a starch-coated matrix of gelatin*, sucrose and maize (corn) oil. dl-α-Tocopherol and ascorbyl palmitate are added as antioxidants.

Dispersibility

Canthaxanthin 10% CWS/N is dispersible in water, yielding orange-red to red colorations.

Canthaxanthin 10% RVI

Canthaxanthin 10% RVI is a red-violet powder. The individual particles contain canthaxanthin finely dispersed in a matrix of gelatin and vegetable oil.

dl-α-Tocopherol and ascorbyl palmitate are added as antioxidants, and silicon dioxide for the improvement of flowability.

Dispersibility

Canthaxanthin 10% RVI is dispersible in water, yielding red-violet to red colorations.

Canthaxanthin 1% CWS/N

This cold-water-soluble (spray-dried) form is a fine orange-red powder. The individual particles contain canthaxanthin finely dispersed in a matrix of maltodextrin, sucrose, gelatin*, maize (corn) oil.

Ascorbyl palmitate, sodium ascorbate and dl-α-tocopherol are added as antioxidants.

Dispersibility

Canthaxanthin 1% CWS/N is dispersible in cold water, yielding orange-red to red colorations.