



Beta Carotene Basics

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<http://www.brainshark.com/dsmnutritional/vu?pi=zFFzx410jzBO2Dz0>

Source, Structure & Function

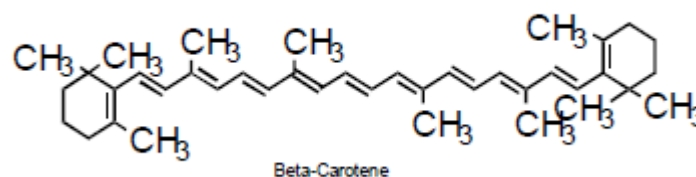


Source

- β-Carotene is one of more than 600 carotenoids found in nature
- Natural food sources include yellow/orange fruits and vegetables (carrots, cantaloupes, apricots) and dark green leafy vegetables (kale, spinach, broccoli)

Structure

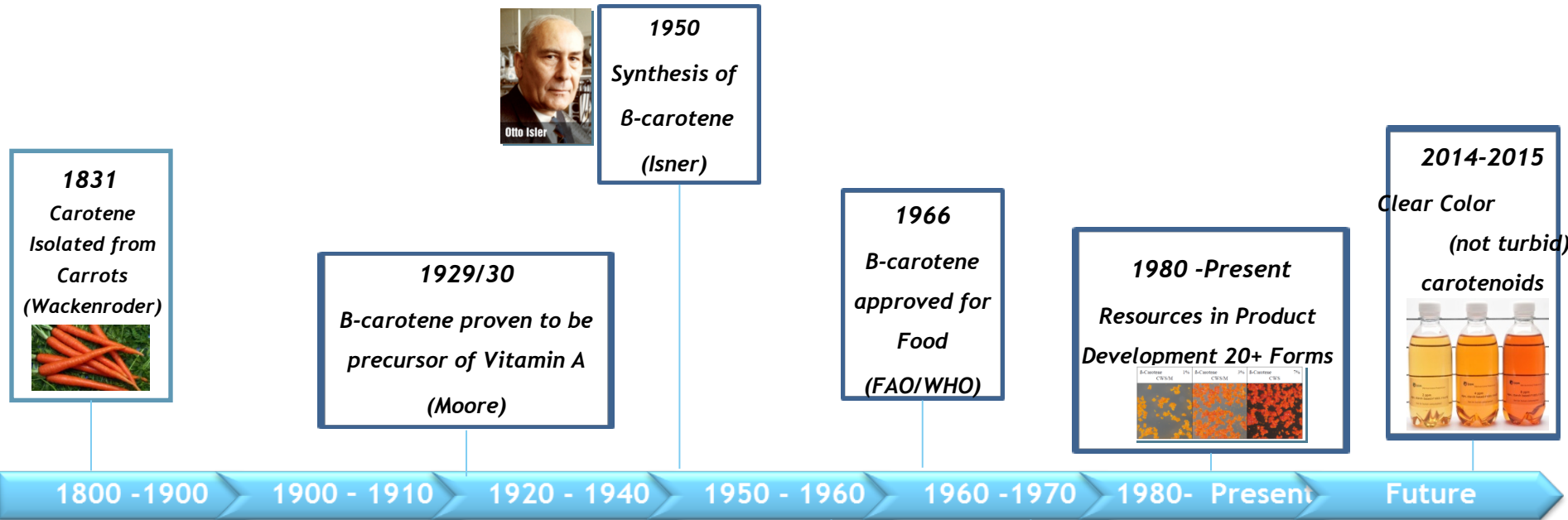
- Carotenoids are long hydrocarbons divided into:
 - Carotenes (without oxygen)
 - Xanthophylls (with oxygen)
- β-Carotene consists of a long chain (40 carbon atoms) of conjugated double bonds with a six-carbon ring on each end
- The long chain of conjugated double bonds is responsible for the orange color
- Exists as *all-trans* β-Carotene in nature



Function

- Most common carotenoids found in blood plasma are alpha-carotene, beta-carotene, and beta-cryptoxanthin (sources of provitamin A) and lycopene, lutein, and zexanthin (no activity)
- β-Carotene is the most abundant and efficient source of provitamin A in foods
- 50 carotenoids are known to have some provitamin A activity


β-Carotene: A Bright History



1831
Carotene Isolated from Carrots (Wackenroder)



1950
Synthesis of B-carotene (Isner)



1929/30
B-carotene proven to be precursor of Vitamin A (Moore)

1966
B-carotene approved for Food (FAO/WHO)

1980 - Present
Resources in Product Development 20+ Forms

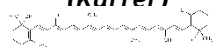
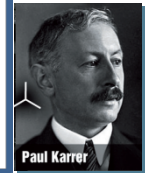


2014-2015
Clear Color (not turbid) carotenoids




1907
Molecular Formula Carotene
 $C_{40}H_{56}$
(Willstatter & Mieg)

1930/31
Chemical Structure B-carotene (Karrer)





1954
Commercial Production B-carotene (Roche/DSM)



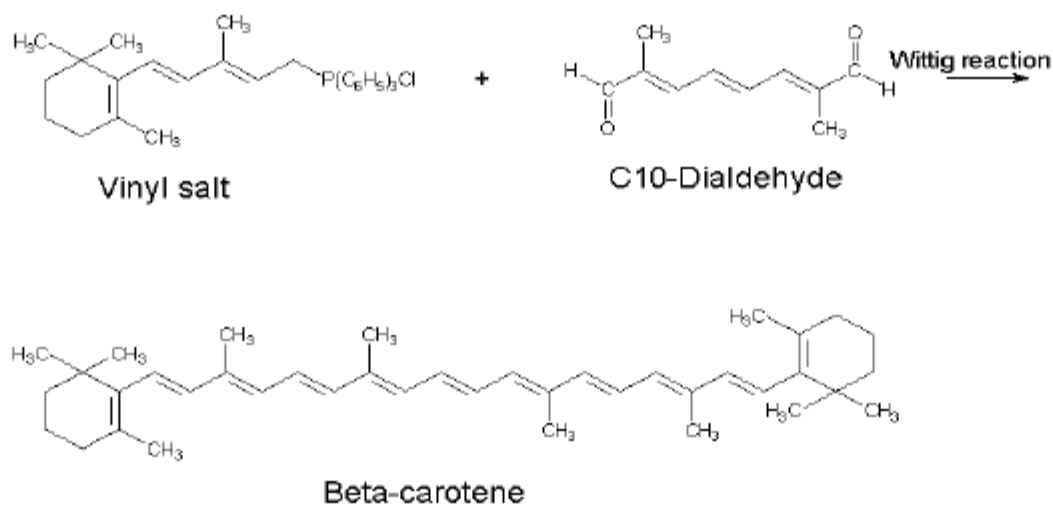
1979
B-carotene receives GRAS status in the USA (FDA)

2007-2008
Introduction of B-carotene 15% LCS



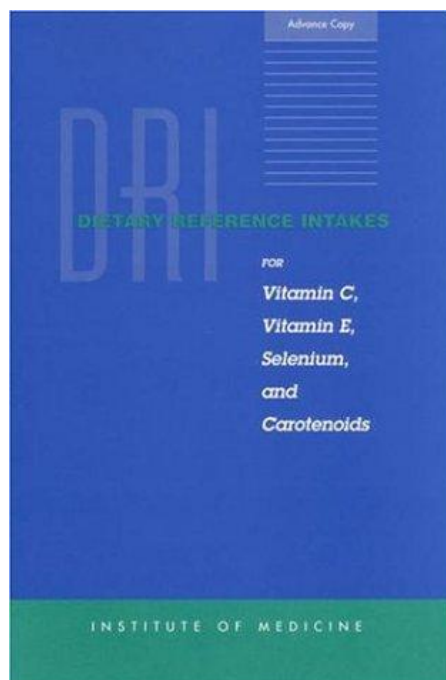

Industrial Production

- ∇ β -Carotene is produced either by a chemical (nature identical) or a fermentation process (natural source)
- Commercially available since 1954 in crystalline form (Roche/DSM) and since 1960 (BASF)
- Roche's original synthesis method was based on the Grignard reaction (enol-ether condensation) and followed the $C_{19}+C_2+C_{19}$ principle
- Today DSM is following the Wittig reaction and follows the $C_{20}+C_{20}$ principle



Dietary Reference Intakes (DRI)

- ★ DRIs are not currently established for β -Carotene, but research continues to support its role as a micronutrient



Source: IOM

Vitamin A (Retinol)

Age	Males & Females	Pregnancy	Lactation
years	$\mu\text{g}/\text{day}$	$\mu\text{g}/\text{day}$	$\mu\text{g}/\text{day}$
1-3	300	n/a	n/a
4-8	400	n/a	n/a
9-13	600	n/a	n/a
14-18	900/700	750	1200
19+	900/700	770	1300

* Allowable levels of nutrients vary depending on national regulations and the final application

Health Benefits of Beta-Carotene

- Dietary source of provitamin A that selectively converts to Vitamin A
- Antioxidant (radical scavenger and singlet oxygen quencher)
- Sun protection (UV-filter)
- After longterm intake (18 years), b-Carotene has a beneficial effect on some aspects of learning and memory

Carotenoids with Provitamin A Activity

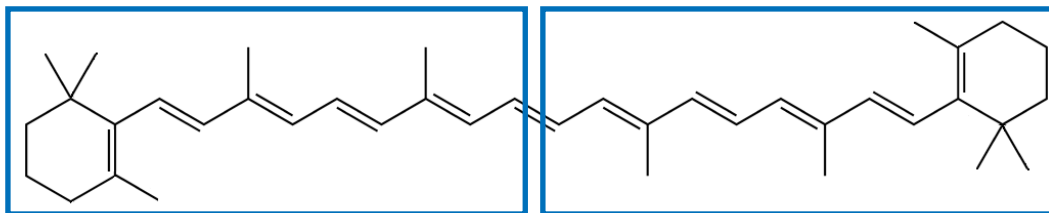
6 mg β -Carotene ¹
correspond to
1 mg Retinol / Vit A

2 mg β -Carotene ²
correspond to
1 mg Retinol / Vit A

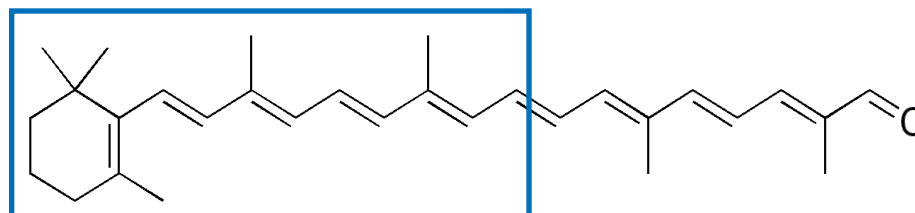
Provitamin A active,
but not allowed
to claim

Vitamin A

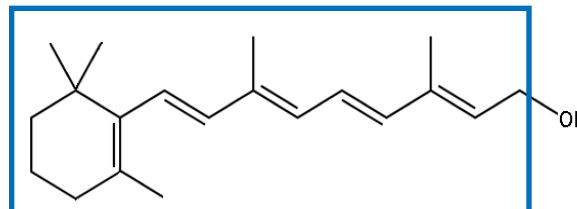
β -Carotene



β -Apo-8'-Carotenal



Retinol



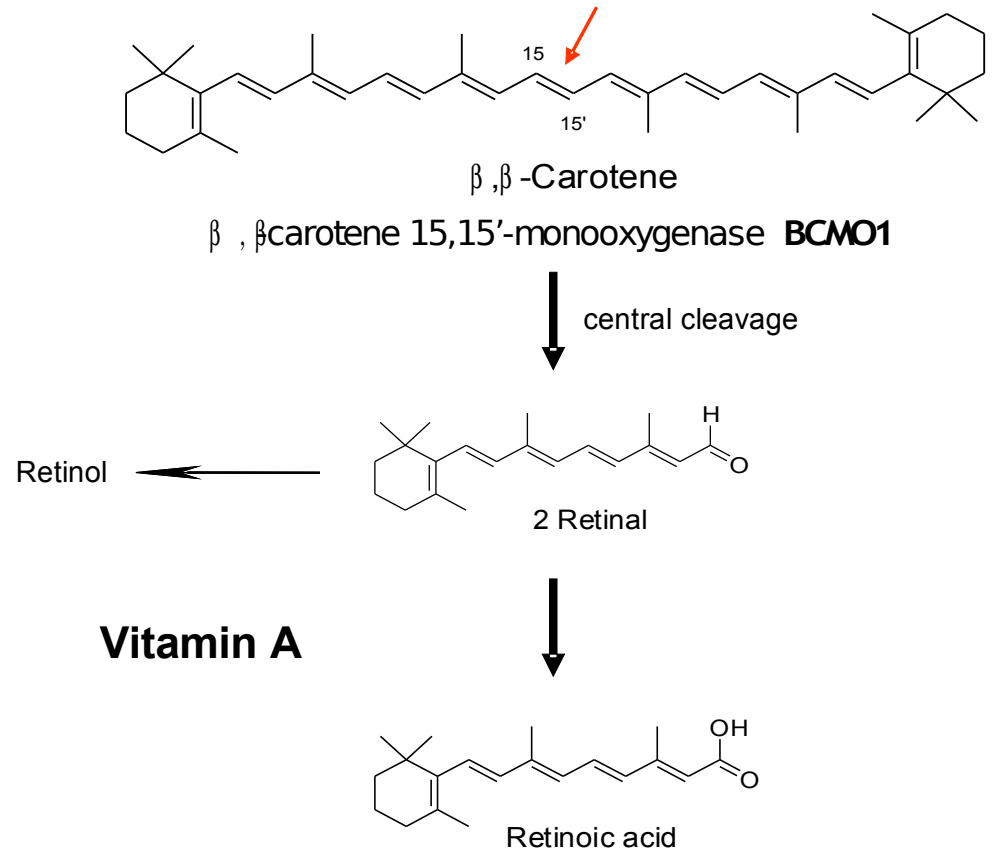
¹ According to the FAO/WHO. 1mg BC = 556.6 IU Vitamin A

² According to the FDA. 1mg BC = 1667 IU Vitamin A

Provitamin A Pathway

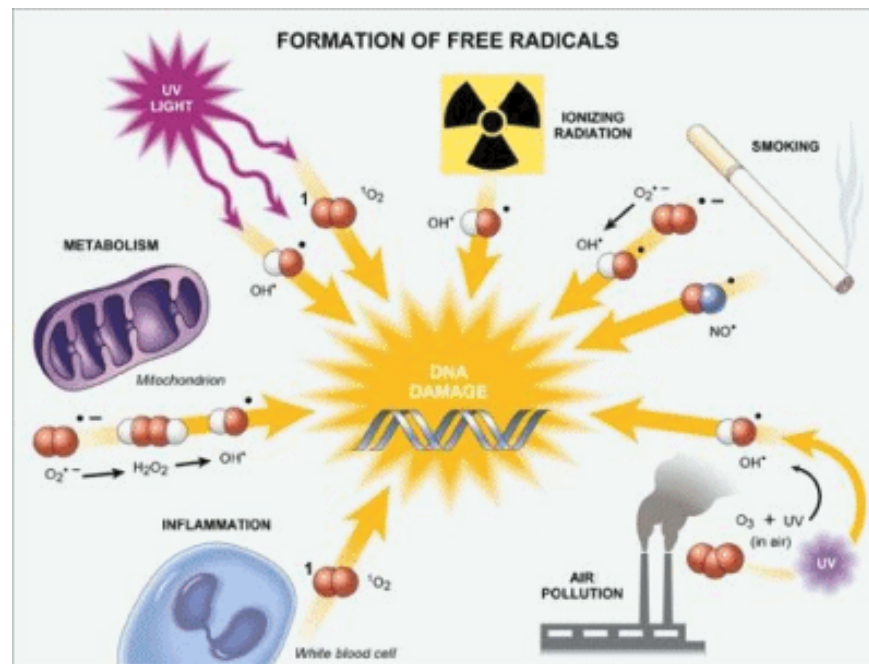
β -Carotene cleavage into 2 molecules of *all-trans* retinal

- Two molecules of Vitamin A are generated from one molecule of β -Carotene
- Polymorphisms with a high prevalence in Caucasians (XY%) were found in the BCMO1 gene
- Reduced activity of β -Carotene mono-oxygenase due to polymorphisms leads to reduced formation of vitamin A
- β -Carotene is a very safe form of Vitamin A since the body converts based on need. This prevents hypervitaminosis A.
- Excess Beta Carotene is stored in the fat tissues and liver



Powerful Antioxidant

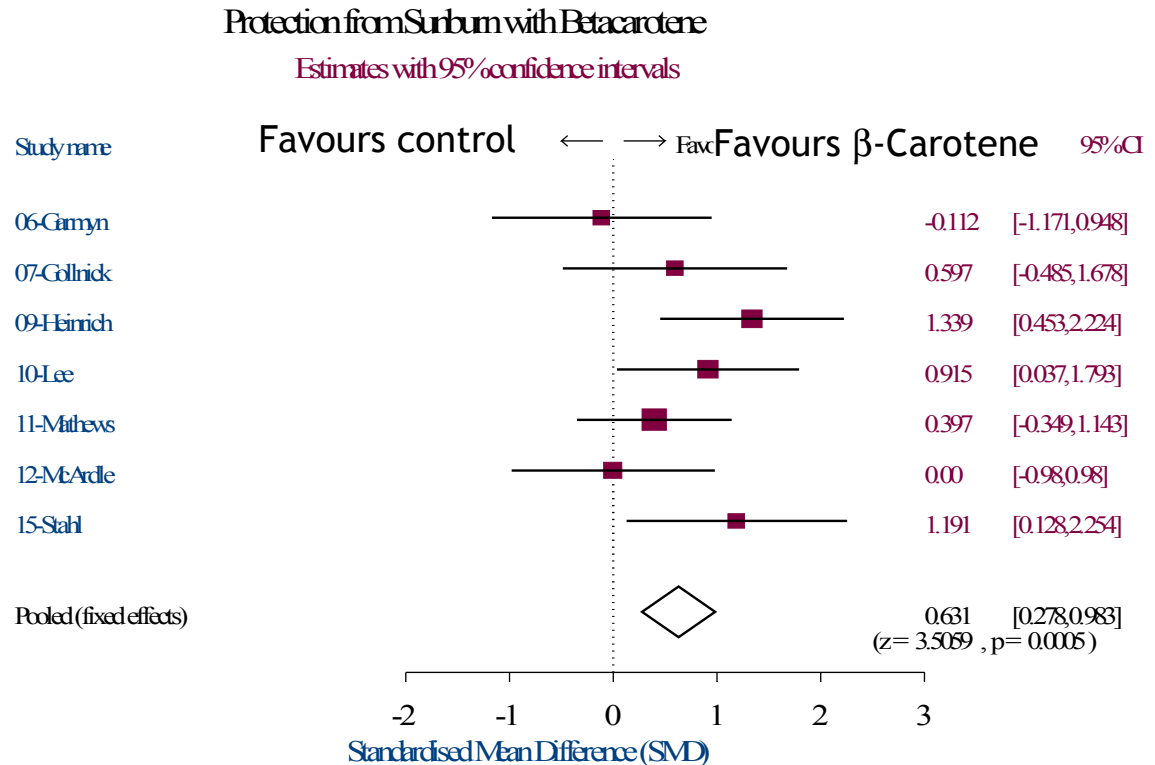
- β -Carotene reacts with reactive oxygen species (ROS) such as peroxy ($\text{ROO}\cdot$) and hydroxy ($\text{HO}\cdot$) radicals as well as singlet oxygen ($^1\text{O}_2$)
- Oxidation of carotenoids by ROS causes a loss in color
- Vitamin C and Vitamin E synergistically protect β -Carotene



Sun Protection

Sun Protection

- A meta-analysis including 7 clinical studies on the effect of β -Carotene on sunburn reduction revealed a significant protective effect ($P= 0.0005$)



Chronic supplementation with β C results in SPF of ~ 2

Krutmann and Köpcke, 2007

Coloration

B-Carotene is a color additive exempt from certification and may be used in foods (21 CFR 73.95), cosmetics (21 CFR 73. 2095), and drugs (21 CFR 73.1095)

COLOR	SHADE	ADVANTAGES	DISADVANTAGES
Beta-carotene	yellow to orange yellow	<ul style="list-style-type: none"> • good stability to light, heat and pH • vitamin C stable • survives retort • Kosher • has vitamin A activity • retort stable • has antioxidant activity 	<ul style="list-style-type: none"> • susceptible to oxidation • not natural • not easy to use (have to prepare stock solution)



Protecting β -Carotene

The color of β -Carotene is stabilized in the presence of ascorbic acid

- ✓ Use 200-250mg/L to minimize color changes

The effect of natural antioxidants (vitamin C) on β -Carotene over time



Forms Overview & Stability

Water Dispersible Forms	Supplement Forms	Emulsions	Oil Based Forms
Spray Dried Beadlet	Beadlet		Suspension Solution

crystal



in water

product forms



crystal



in oil

form



β -Carotene - Nature-Identical

Water Dispersible & Emulsion Product Forms

β-Carotene 1% CWS/M Powder, cold water dispersible/medium chain triglycerides	JECFA*, Kosher Parve (OU) (BK), Halal	5 25	50 03741.304 50 03741.368	For fortification and coloration of water-based foods, instant products, beverages, puddings, confectionery and milk products. Color range: yellow.
β-Carotene 3% CWS/M Powder, cold water dispersible/medium chain triglycerides	JECFA*, Kosher Parve (OU) (BK), Halal	5	50 03636.304	For fortification and coloration of water-based foods, instant products, beverages, puddings, confectionery and milk products. Color range: yellow.
β-Carotene 7% CWS Powder, cold water dispersible	JECFA*, Kosher Parve (OU) (BK), Halal	10	04 82285.231	For fortification and coloration of beverages, puddings, confectionery and milk products. Color range: clear yellow.
β-Carotene 10% CWS Beadlet ^{tt} , cold water dispersible	JECFA*, Kosher Parve (OU) (BK), Halal	1 5 25	04 34825.268 04 34825.304 04 34825.368	For fortification and coloration of beverages, soups, sauces, cereals and confectionery. Color range: yellow-orange to orange.
β-Carotene 10% CWS/S Beadlet ^{tt} , cold water dispersible/starch	JECFA*, Kosher Parve (OU) (BK), Halal	5 20	04 89999.304 04 89999.341	For fortification and coloration of beverages, soups, sauces, cereals and confectionery. Color range: yellow-orange to orange.
β-Carotene 10% Emulsion Red Liquid emulsion	JECFA*, Kosher Parve (OU) (BK), Halal	6	50 12538.147	For fortification and coloration of juice and non-juice beverages, ice cream, yogurt and salad dressings. Color range: pink to strawberry red.
β-Carotene 10% EM Yellow Liquid emulsion	JECFA*, Kosher Parve (OU) (BK), Halal	5	50 02427.301	For fortification and coloration of juice and non-juice beverages, ice cream, yogurt and salad dressings. Color range: yellow.
β-Carotene 5% EM K Liquid emulsion	JECFA*, Kosher Parve (OU) (BK), Halal	5 25	50 11256.311 50 11256.356	For fortification and coloration of juice and non-juice beverages, ice cream, yogurt and salad dressings. Color range: yellow.

β -Carotene - Nature-Identical

Oil Based Product Forms

β-Carotene 30% FS Fluid suspension	JECFA*, Kosher for Passover-Kitniot (BK), Kosher Parve (OU), Halal	1 5 5 1 [†] 20 [†]	04 27233.266 04 27233.311 04 27233.294 (Origin: France) 50 08735.175 50 08735.199 (Origin: USA)	For soft gelatin capsules. For fortification and coloration of fat-based foods. Color range: yellow.
β-Carotene 30% FS Ph Fluid suspension	JECFA*, Kosher for Passover-Kitniot (BK), Kosher Parve (OU), Halal	5	50 14387.294	For pharmaceutical preparations.
β-Carotene 30% FS/SF Fluid suspension Sunflower oil	JECFA*, Kosher for Passover-Kitniot (BK), Kosher Parve (OU), Halal	5	50 00238.311	For soft gelatin capsules. For fortification and coloration of fat-based foods. Color range: yellow.
β-Carotene 22% HSS Fluid suspension, heat stable	JECFA*, Kosher Parve (OU)	1 20	04 66042.913 04 66042.313	For soft gelatin capsules. For coloration of popcorn, popping and frying oils. Color range: yellow.

β-Carotene - Nature-Identical

Supplement Forms

BetaTab® 10% E Beadlet™, tablet grade	JECFA*	5 25	04 34140.304 04 34140.368	For effervescent tablets.
BetaTab® 20% S Beadlet™, tablet grade/starch	JECFA*, Kosher Parve (OU) (BK), Kosher Ko, Halal	5 25	50 04004.304 50 04004.368	For direct compression tablets and hard gelatin capsules.
BetaTab® 20% S Ph Beadlet™, tablet grade/starch	JECFA*, Kosher Parve (OU) (BK), Kosher Ko, Halal	25	50 14352.368	For pharmaceutical preparations.

Stock Solutions

- ✓ Recommended method for adding β -carotene to foods & beverages
- ✓ Applicable for water dispersible forms and oil based fluid suspensions
- ✓ Ensures complete dispersion of active prior to use
- ✓ Allows the user to volumetrically dose into the sample
- ✓ Standardizes concentration to 1mg of β -carotene per 1ml of solution

The Food Coloration Manual provides detailed preparation methods for each form



Specialty Forms for Foods & Beverages

Beta Carotene 15% LCS
@ 20% DV Vitamin A



Beta Carotene 10%B is a cross linked beadlet



Beta Carotene - competitive environment

BASF / COGNIS

- Comprehensive product portfolio similar to DSM
- Backward integrated to crystal production
- Higher focus on feed than DSM, but Cognis acquisition has renewed focus on human nutrition

ALLIED

- Backward integration
- Human nutrition focus on EU, China, USA
- Portfolio similar to DSM and now includes Apocarotenal and β -Carotene emulsions

DIVIS

- Can synthesize crystals and forms
- Based in India
- Focused on export to EU and USA
- Considered lower end forms

Chinese producers (ZMC, NHU)

- Multipurpose and backward integrated plants
- Pricing for volume
- Very active in animal feed
- Sell via local distributors

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