Chemistry of carotenoids pdf

Class of chemical compounds; The yellow, orange or red plant pigments of the Orange Ring surrounding Grand Prismatic Spring are associated with carotenoid molecules produced by algae and bacteria mats. Carotenoids (/kəˈrɒtɪnɔɪd/), also called tetratepenoids, are yellow, orange and red organic pigments produced by plants and algae, as well as several bacteria and fungi. Carotenoids give a characteristic color to pumpkins, carrots, corn, tomatoes, canary, flamingos, salmon, lobster, shrimp and daffodils. Carotenoids can be derived from fats and other major organic metabolic building blocks by all of these organisms. The only terrestrial arthropods that are known to produce carotenoids are aphids, and spider mites, which have acquired the ability and genes from fungi. Carotenoids from the diet are stored in the fatty tissues of animals, and exclusively carnivorous animals receive compounds from animal fat. In the human diet, the absorption of carotenoids is improved by eating fat. The preparation of carotenoid-containing vegetables in oil increases the bioavailability of carotenoids. There are more than 1,100 known carotenoids that can be further classified into two classes, xanthophils (which contain oxygen) and carotene (which are purely hydrocarbons and contain no oxygen). All of them are derivatives of tetraterpens, which means that they are made from 8 refined molecules and contain 40 carbon atoms. In general, carotenoids absorb wavelengths from 400 to 550 nanometers (purple to green light). This results in the compounds being deeply painted yellow, orange or red. Carotenoids are the dominant pigment in the autumn coloration of leaves about 15-30% of tree species, but many plant colors, especially red and purple, are due to polyphenols. The macular pigments of the human eye carotenoids serve two key roles in plants and algae: they absorb light energy for use in photosynthesis, and they provide photoprotectics using non-photochemical hardening. Carotenoids containing unsigned beta-ionan rings (including beta-carotene, alpha-carotene, beta-cryptoxanthin and gamma-carotene) have vitamin A activity (meaning that they can be converted into retinol). In the eye lutein, meso-zeaxanthin and zeaxanthin are present as macular pigments, the value of which in visual function, at this point in 2016, remains in the stage of clinical research. The biosynthesis pathway of carotenoide synthesis The main building blocks of carotenoids are isopentenyl diphosphate (IPP) and dimethylallyl diphosphate (DMAPP). These two isopren isomers are used to create different compounds depending on the biological pathway used to synthesize isomers. Plants are known to use two different pathways IPP: cytozole pathway of mevalanic acid (MVA) and plastidic methyleritritol methyleritritol (MEP). In animals, cholesterol production begins with the creation of IPP and DMAPP using MVA. For carotenoids, manufacturing plants use MEP to create IPP and DMAPP. The mep path results in a 5:1 IPP:DMAPP mix. IPP and DMAPP undergo several reactions, resulting in the main carotenoid precursor, gerangeranil diphosphate (GGPP). GGPP can be converted into carotene or xanthophilli by going through a number of different steps within the carotenoids biosynthetic pathway. The mep path of Glyceraldehyde 3-phosphate and pyruvat, intermediate photosynthesis, is converted into deoxy-D-xylose 5-phosphate (DXP) with the help of the DXP synthase catalyst (DXS). DXP reductoisomerase reduces and rearranges molecules inside DXP in the presence of NADPH, forming a MEP. Further, MEP is converted into 4-(citidine 5'-diphosfo)-2-C-methyl-D-erytrotol (CDP-ME) in the presence of CTP through the enzyme cytyltransferase MEP. CDP-ME is then converted, in the presence of ATP, into 2-phospho-4-(citidine 5'-difosfo)-2-C-methyl-D-erytrotol (CDP-ME2P). Conversion to CDP-ME2P is catalyzed by CDP-ME kinase enzyme. Then CDP-ME2P is converted into 2-C-methyl-D-erytrotol 2.4-cyclodiphosphate (MECDP). This reaction occurs when MECDP synthase catalyzes the reaction and CMP is removed from the CDP-ME2P molecule. THEN MECDP is converted into (e)-4-hydroxy-3-methylbut-2-en-1-yl diphosphate (HMBDP) via HMBDP synthase in the presence of flavodoccin and NADPH. HMBDP is reduced to IPP in the presence of ferredoxin and NADPH enzyme IMBDP redukase. The last two steps involving HMBPD synthases and reducts can only occur in fully

anaerobic environments. IPP can measure DMAPP through IPP isomerase. Carotenoid biosynthetic pathway Conversion of phytoen in lycopene in plants and cyanobacteria (left) is different compared to bacteria and fungi (right). Two GGPP molecules condense through phytoen synthase (PSY), forming a 15-cis isomer of phytoen. The subsequent conversion to translycopine depends on the body. Bacteria and fungi use one enzyme, bacterial phytoen desaturase (CRTI) for catalysis. Plants and cyanobacteria, however, use four enzymes for this process. The first of these enzymes is plant-type phytoenomic desaturasis, which introduces two additional double bonds into 15-cis-phytolene by dehydrogenization and isomerizes two of the existing double bonds from trance to cis, producing 9.15,9'-tri-cis-ζ-carotene. The central double bond of this tri-cis-ζ-carotene is measured by zeta-carotene isomerase z-ISO and as a result 9.9'-di-cis-ζ-carotene dehydrogenated again through ζ-carotene desaturase (NDD). This again introduces two double bonds, resulting in 7,9,7',9'-tetra-cis-lycopene. CRTISO, carotenoid isomeras, is needed to convert cis-lycopene into If there is a reduced FAD. This all-trans lycopene is cyclical; cyclization generates carotenoids, which can be distinguished from end groups. There can be either a beta ring or an Epsilon ring, each of which is generated by a different enzyme (lycopene beta-cyclase beta-LCY or lycopene epsilon-cyclase epsilon-LCY). Alpha carotene is produced when all-trans lycopene first undergoes a reaction with Epsilon-LCY followed by a second reaction with beta-LCY; while beta-carotene is produced by two reactions with beta-LCY. Alpha and beta-carotene are the most common carotenoids in plant photosystems, but they can still be further converted into xanthophylls using beta-hydrolase and epsilon-hydrolase, leading to various xanthophyls. Both DXS and DXR are thought to be the rate-determining enzymes that allow them to regulate carotenoids levels. This was found in an experiment where DXS and DXR were genetically overexpressed, leading to an increase in the expression of carotenoids as a result of seedlings. In addition, J-protein (J20) and heat shock protein 70 (Hsp70) are thought to be involved in post-transcription regulation of DXS activity, so mutants with defective J20 activity show a decrease in the activity of the DXS enzyme when the inactive DXS protein is accumulated. Regulation can also be caused by external toxins that affect the enzymes and proteins needed for synthesis. Ketoclomazone is derived from herbicides applied to the soil and binds to DXP synthase. This inhibits DXP synthase, preventing DXP synthesis and hunting the way of MEP. The use of this toxin leads to a decrease in the level of carotenoids in plants grown in contaminated soil. phosmidomecin, an antibiotic, is a competitive DXP inhibitor reductoisomerase because of its similar enzyme structure. The application said the antibiotic prevents the reduction of DXP, again stop the path of THE MEP. The structure and function of the general structure of carotenoids: a poly tail with double connections, possible terminal rings The structure of carotenoids gives biological abilities including photosynthesis, photoprosthesis, plant coloration and cell signaling. The overall structure of carotenoids is a plastic chain consisting of 9-11 double bonds and possibly ending in rings. This structure of conjuged double bonds leads to a high reduction in potential, or the ability to transmit electrons throughout the molecule. Carotenoids can transmit energy arousal in one of two ways: 1) singlet singlet transfer energy from carotenoids to chlorophyll, and 2) triple transmission of energy from chlorophyll to carotenoide. Singlet energy transmission is a lower transmission of energy and is used during photosynthesis. The length of the poly tail provides the absorption of light in the photosynthetic range; as soon as he energy, it becomes becoming then transfers the excited electrons to chlorophyll for photosynthesis. Triple triple transfer is a higher energy state and is important in photo protection. Both light and oxygen produce harmful species during photosynthesis, with reactive oxygen (ROS) being the most destructive. As these high ROS energies are produced in chlorophyll the energy is transferred to the carotenoid polyene tail and undergoes a series of reactions in which electrons are moved between carotenoids by connections to find the most balanced position (lowest energy position) for the carotenoid. The length of the carotenoids also plays a role in the coloration of the plants, as the length of the poly tail determines what wavelengths of light the plant will absorb. Wavelengths that are not absorbed are reflected and what we see as the color of the plant. Thus, different species will contain carotenoids with different tail lengths, allowing them to absorb and reflect different colors. Carotenoids are also involved in different types of cellular signaling. They are able to signal the production of absicidic acid, which regulates plant growth, seed shrinkage, embryo maturation and germination, cell division and elongation, floral growth and stressful reactions. Properties Main articles: carotene and Xantophylla Gac fruit, lycopene-rich Ingesting carotenoids-rich foods affect flamingo plumage. Carotenoids belong to the category of tetratepenoids (i.e. contain 40 carbon atoms built of four terpenes, each containing 10 carbon atoms). Structurally carotenoids take the form of a polyene hydrocarbon chain, which is sometimes stopped by rings, and may or may not have additional oxygen atoms attached. Carotenoids with molecules containing oxygen, such as lutein and zeaxanthin, are known as xanthophils. Non-oxygenated (oxygen-free) carotenoids such as α-carotene, β carotene and lycopene are known as carotene. Carotene usually contains only carbon and hydrogen (i.e. hydrocarbons) and are in the sub-class of unsaturated hydrocarbons. Their color, from pale yellow to bright orange to deep red, is directly related to their structure. Xantophiles are often yellow, hence their class name. Double carbon-carbon bonds interact with each other in a process called conjugation, allowing electrons in the molecule to move freely through these areas of the molecule. As the number of double bonds increases, the electrons associated with the conjuged systems have more room to move and require less energy to change states. This reduces the range of light energies absorbed by the molecule. As more wavelengths of light are absorbed from the longer end of the visible spectrum, the connections become increasingly red.com. Carotenoids like lipophilic due to the presence of long long aliphatic chains, as in some fatty acids. The physiological absorption of these fat-soluble vitamins in the human body and other organisms directly depends on the presence of fats and bile salts. Beta-carotene products found in pumpkins, sweet potatoes, carrots and winter courgettes are responsible for their orange-yellow colors. Dried carrots have the highest amount of carotene from any food per 100-gram serving, measured in equivalents of retinol activity (provitamin A equivalents). Vietnamese gac fruits contain the highest known concentration of carotenodin lycopene. Although green, cabbage, spinach, collared greens and turnip greens contain significant amounts of beta-carotene. The flamingo diet is rich in carotenoids, giving these birds orange feathers. Physiological Effects Reviews of epidemiological studies looking for correlations between carotenoids in food intake and clinical outcomes have come to different conclusions: a 2015 review found that foods high in carotenoids appear to be protective against head and neck cancers. Another 2015 review looking at whether caretenoids can prevent prostate cancer found that while several studies have found correlations between diets rich in carotenoids appear to have a protective effect, evidence is lacking to determine whether this is due to carotenoids per se. Another 2014 review found no conflicting results in studies of dietary carotenoids and breast cancer risk. Carotenoids are also important components of the dark brown melanin pigment that is found in the hair, skin and eyes. Melanin absorbs high energy light and protects these organs from intracellular damage. Several studies have observed the positive effects of high-cotonoid diets on the texture, clarity, color, strength and elasticity of the skin. A 1994 study noted that a high carotenoid diet helps reduce symptoms of visual stress (dry eye, headaches and blurred vision) and improve night vision. Humans and other animals are mostly incapable of synthesizing carotenoids, and should receive them through their diet. Carotenoids are a common and often decorative feature in animals. For example, the pink color of salmon, as well as the red color of cooked lobster and the scales of yellow morphing common wall lizards are caused by carotenoids. It has been suggested that carotenoids are used in decorative traits (for extreme examples to see puffin birds) because, given their physiological and chemical properties, they can be used as visible indicators of individual health, and are therefore used by animals when selecting potential mates. The colors of yellow and orange plants in autumn carotenoids that are after chlorophyll degrades during the season. Apricots rich in carotenoids The most common carotenoids include lycopene and precursor vitamin A β carotene. In plants, xanthophyll lutein is the most common carotenoide and its role in preventing age-related eye disease is being investigated. Lutein and other carotenoid pigments found in mature leaves are often not obvious due to the camouflage presence of chlorophyll. When chlorophyll is not present, as in autumn foliage, yellow and oranges of carotenoids predominate. For the same reason, carotenoids of color often prevail in ripe fruit after being exposed to the disappearance of chlorophyll. Carotenoids are responsible for shiny yellows and oranges that are a shade of foliage (such as dying autumn leaves) of certain species of hardwoods like gycoria, ash, maple, yellow poplar, aspen, birch, black cherry, sycamore, cotton wood, sassafras and olha. Carotenoids are the dominant pigment in the autumn coloration of leaves about 15-30% of tree species. However, red, purple and their mixed combinations, which adorn autumn foliage, usually originate from a different group of pigments in cells called anthocyanins. Unlike carotenoids, these pigments are not present in the leaf during the entire current season, but are actively produced at the end of the summer. Aroma chemical products of carotenoids degradation such as ions, damagons and damascenones are also important fragrance chemicals that are widely used in the perfume and perfume industries. Both β-damascenone and β-ionon, although low concentrations in pink distillates are key odor compounds in colors. In fact, the sweet floral smells present in black tea, aged tobacco, grapes, and many fruits are due to aromatic compounds as a result of the decay of carotenoids. Some carotenoids are produced by bacteria to protect themselves from an oxidative immune attack. The golden pigment that gives some strains of Staphylococcus aureus to their name (Golden and Gold) is a carotenoids called staphylococcuscin. This carotenoids is a virulence factor with antioxidant action that helps the microbe avoid death by reactive oxygen used by the host immune system. Natural carotenoids Hydrocarbons Likopersen 7.8,11,12,15,7',8',11',15'-Decahydro-γ,γ-carotene phytofluin lycopene 15-cis-7 ,8,11,12,7',-8'-Hexahydro-γ,γ-carotene-torulen 3',4'-Didehydro-β,γ-carotene α-zaicoten 7'8'-Dihydro-ε,γ--Carotene beta-carotene Alcohol aloxantin Bacteritorubine 2.2'-Bis (3-hydroxy-3-methylbutyl)-3,4',4'-tetradehydro-1,2'-2'-tetrahydro-γ,γ-carotene-1.1 '-diol cynthiaxant Pechtensantin Cryptomonaxanthin (3R,3'R)-7,8',8'-Tetradehydro-β,β-carotene-3.3'-diol crustaxanthin β,-carotene-3'4',4'-tetrol OH-Chlorobaccene 1',2'-Ілилро-Ј,с-каротен-1'-ol Лороксантин b,е-каротин-3,19,3'-триол Ј Iтеин (3R,3'R,6'R)-b 3,е-b каротин-3,3 -диол ликоксантин с,с-каротен-16-оlI Ј олоп ин 1,2-Ілилро-с,с-каротен-л-олЈ Ролопинол ок.к.а. Warmingol 13-cis-1,2-Dihydro-γ,γ-carotene-1,20-diol Saproxanthin 3',4'-Didehydro-1',2'-dihydro-β,γ-carotene-3,1'-diol Zeaxanthin Glycosides Oscillaxanthin 2,2'-Bis(β-L-rhamnopyranosyloxy)-3,4,3',4'-tetradehydro-1,2,1',2'-tetrahydro-γ,γ-carotene-1,1'-diol Phleixanthophyll 1'-(β-D-Glucopyranosyloxy)-3',4'-didehydro-1',2'-dihydro-β,γ-caroten-2'-ol Ethers Rhodovibrin 1'-Methoxy-3',4'-didehydro-1,2,1',2'-tetrahydro-γ,γ-caroten-1-ol Spheroidene 1-Methoxy-3,4-didehydro-1,2,7',8'-tetrahydro-γ,γ-carotene Epoxides Diadinoxanthin 5,6-Epoxy-7',8'-didehydro-5,6-dihydro—carotene-3,3-diol Luteoxanthin 5,6: 5',8'-Diepoxy-5 ,6,5',8'-тетрагидро-β,β-каротин-3,3'-диол Мутуток сантин Цитроксантин Цеаксантин фураноксид 5,8-Ероху-5,8-дигидро-β,β-каротин-3,3'-диол неохром 5 ',8'-Ероху-6,7-дидегидро-5,6,5',8'-тетрагидро-β,β-каротин-3,5,3'-триол Foliachrome Trollichrome Vaucheriaxanthin 5',6'-Ероху-6,7-додегидро-5 ,6,5',6'-тетрагидро-β,β-каротин-3,5,19,3'-тетрол Альдегиды Родопинал Warmingone 13-cis-1-Гидрокси-1,2-дигидро-γ,γ-каротен-20-аль Торуларходиналдех айд 3',4'-Дидегидро-β,γ-каротен-16'-аль кислоты и кислотные эфиры Торулярородин 3',4'-Дидегидро-β,γ-каротен-16'-ойная кислота Торулярходин метиловый эфир Метил 3' ,4'-додегидро-β ,γ-каротен-16'-оate Ketones Astacene Astaxanthin Canthaxanthin[34] a.k.a. Aphanicin, Chlorellaxanthin β,β-Carotene-4,4'-dione Capsanthin (3R,3'S,5'R)-3,3'-Dihydroxy-β,к-caroten-6'-one Capsorubin (3S,5R,3'S,5'R)-3,3'-Dihydroxy-к,к-carotene-6,6'-dione Cryptocapsin (3'R,5'R)-3'-Hydroxy-β,к-caroten-6'-one 2,2'-Diketospirilloxanthin 1,1'-Dimethoxy-3,4,3',4'-tetradehydro-1,2,1',2'-tetrahydro-γ,γ-carotene-2,2'-dione Echinenone β,β-Caroten-4-one 3'-hydroxyechinenone Flexixanthin 3,1'-Dihydroxy-3',4'-didehydro-1',2'-dihydro-β,γ-caroten-4-one 3-OH-Canthaxanthin a.k.a. Adonirubin a.k.a. Финикоксантин 3-Гидрокси-β,β-каротин-4,4'-дион Гидроксисфериоденон 1'-Гидрокси-1-мезокси-3 ,4-дилегидро-1,2,1',2',7',8'-гексагилро-с,с caroten-2-one Okenone 1'-Methoxy-1',2'-dihydro-c,c-caroten -4'-один пектенолон 3,3'-Ілилрокси-7',8'-лилелилро-b,b-каротен-4-олин Ј еникон. Дегидроадонирубин 3-Гидрокси-2,3-дидегидро-β,β-каротин-4,4'-дион феникоптерон β,ε-каротен-4-один Рубиксанон 3-Гидрокси-β,γ-каротен-4'-один Сифоналксантин 3,19,3'-Тригидрокси-7,8-дигидро-β,ε-каротен-8-один Эстеры спиртов Астацеин 3,3'-Биспалмитойлокси-2,3,2',3'тетрадегидро-β,β-каротин-4,4'-дион или 3,3'-дигидрокси-2,3',3'-тетрадегидро-β,β-каротин-4,4'-дион дипальмитат Фукоксантин 4,4'-дион дипальмитат Фукоксантин 4,4'-дионЗ'-Ацетокси-5,6-эпоксидная-3,5'-дигидрокси-6',7'-дидегидро-5,6,7,8,5',6'-гексагидро-β,β-каротен-8-один изофукоксантин Physalien Zeaxanthin (3R,3'R)-3,3'-Bispalmitoyloxy-β,β-carotene or (3R,3'R)-β,β-carotene-3,3'-diol Siphonein 3,3'-Dihydroxy-19-lauroyloxy-7,8-dihydro-β,ε-caroten-8-one or 3,19,3'-trihydroxy-7,8-dihydro-β,ε-caroten-8-one 19-laurate Apocarotenoids β-Apo-2'-carotenal 3',4'-Didehydro-2'-apo-b-caroten-2'-al Apo-2-lycopenal Apo-6'-lycopenal 6'-Apo-y-caroten-6'-al Azafrinaldehyde 5,6-Dihydroxy-5,6-dihydro-10'-apo-β-caroten-10'-al Bixin 6'-Methyl hydrogen 9'-cis-6,6'-diapocarotene-6,6'-dioate Citranaxanthin 5',6'-Dihydro-5'-apo-β-caroten-6'-one or 5',6'-dihydro-5'-apo-18'-nor-β-caroten-6'-one or 6'-methyl-6'-apo-β-caroten-6'-one Crocetin 8,8'-Diapo-8,8'-carotenedioic acid Crocetinsemialdehyde 8'-Oxo-8 ,8'-diapo-8-carotenoic acid Crocin Digentiobiosyl 8,8'-diapo-8,8'-carotenedioate Hopkinsiaxanthin 3-Hydroxy-7,8-didehydro-7',8'-dihydro-7'-apo-b-carotene-4,8'-dione or 3-hydroxy-8'-methyl-7,8-didehydro-8'-apo-b-carotene-4,8'-dione Methyl apo-6'-lycopenoate Methyl 6'-apo-y-caroten-6'-oate Paracentrone 3,5-Dihydroxy-6,7-didehydro-5,6,7',8'-tetrahydro-7'-apo-b-caroten-8'-one or 3,5-dihydroxy-8'-methyl-6,7-didehydro-5,6-dihydro-8'-apo-b-caroten-8'-one Sintaxanthin 7',8'-Dihydro-7'-apo-b-caroten-8'-one or 8'-methyl-8'-apo-b-caroten-8'-one Nor- and seco-carotenoids Actinioerythrin 3,3'-Bisacyloxy-2,2'-dinor-b,b-carotene-4,4'-dione β-Carotenone 5,6:5',6'-Diseco-b,b-carotene-5,6,5' ,6'-тетрон Перидинин 3'-Ацетокси-5,6-эпокси-3,5'-дигидроксил-6',7'-дидегидро-5,6',6'-тетрагидро-12',13',20'-тринор-б,б-каротен-19,11-11 Олид Пирроксантининол 5,6-эпокси-3,3'-дигидроксия-7',8'-дидегидро-5,6-дигидро-12',13',20'-тринор-б,б-каротен-19,11-олид полу-α-каротенон 5,11 6-Seco-b,e-каротин-5,6-дион Полу-β-каротенон 5,6-секо-б,б-каротин-5,6-дион или 5',6'-секо-б,б-каротин-5',6'-дион Трифасияксасин 3-Гидроксисеми-б-кар Отенон 3'-Гидрокси-5,6-секо-б,б-каротин-5,6-дион или 3-гидрокси-5',6'-секо-б,б-каротин-5',6'-дион ретро-каротиноиды и ретро-апо-каротиноиды Эшшольцсантин 4' ,5'-Дидегидро-4,5'-ретро-б,б-каротин-3,3'-диол Эшшольцкантон 3'-Гидрокси-4',5'-дидегидро-4,5'-ретро-б,б-каротен-3-один родоксантин 4',5'-Дидегидро-4,5'-ретро-б,б-каротин-3,3'-дион Тангераксантин 3-Гидрокси-5'-метил-4,5'-ретро-5'-апо-б-каротен-5'-один или 3-гидрокси-4,5'-ретро-5 '-апо-б-каротен-5'-один Высший каротиноиды Нонапредноксантин 2-(4-Гидрокси-3-метил-2-бутенил)-7',8',11',12'-тетрагидро-е,у-каротин Декапринокс антин 2,2'-Бис(4-гидрокси-3-метил-2-бутенил)-е, е-каротин К.п. 450 2-4-Гидрокси-3-(гидроксиметил)-2-бутенил-2'-(3-метил-2-бутенил)-б,б-каротин К.п. 473 2'--(4-Гидрокси-3-метил-2-бутенил)-2-(3-метил-2-бутенил)-3' ,4'-дидегидро-л',2'-дигидро-β,γ-каротен-1'-оль Бактериоруберин 2,2'-Бис (3-гидрокси-3-метилбутил)-3,4',4 '-тетрадегидро-1,2,1',2'-тетрагидро-γ,γ-каротин-1,1'-диол Смотрите также Список фитохимических веществ в пищевой фитохимии Ссылки - b d e f g h i j Carotenoids. 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