

## Natural Carotenoids a Weapon to Fight against Life Style Related Disorders

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### Abstract

Carotenoids have gained consumer interest because of their unique biological functions to promote human health. They belong to a group of isoprenoid pigments with abundance in nature. These pigments play a fundamental role qualitative specification of both fruits and vegetables. Coloring property of these pigments provide an appealing character to foods. Their biological properties allow them to develop a variety of commercialized products. Such properties involve these pigments in nutraceutical industry to cure life style related disorders, including cardiovascular diseases, cancer, photosensitivity disorders and immune-sensitivity. This review discusses the biological properties and role of carotenoids towards prevention and protection from life style related disorders. Yet there are several research gaps to find out the exact doses for particular diseases.

**Keywords:** Carotenoids; Antioxidants; Food color; Disorders

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### Introduction

Consumers are encircled with colors from green grasslands to forestry's glowing autumn hues. They not only getting the life colors from pigments but also availing the various biological functions necessary to sustain. Pigments are mainly originated from plants and some micro-organisms such as yeast, cyanobacteria, algae, and fungi. Carotenoids are the second most abundant natural colors, and primarily C<sub>40</sub> lipophilic isoprenoid molecules in nature that contains yellow, red and orange colors. These pigments serve as antioxidants that act as membrane protector by scavenging peroxy radicals and O<sub>2</sub>. Their antioxidant property is primarily dependent to structure of pigment. Until now, more than 750 structured carotenoids had been identified that are distributed into two fragments, non-oxygenated known as carotenes and oxygenated carotenoids known as xanthophylls. Many of carotenoids are the precursors of Vitamin A. Carotenoids are among the bioactive phytochemicals attributed in relations to human health that help to reduce dangers from chronic diseases, like cardiovascular disorders, cataract, cancer, eye health, immunity enhancement and macular degeneration [1-10].

Carotenoids are unable to be synthesized in human. They are present in different kinds of fruit and vegetables, with the consumption of these fruits and vegetables, the requirement for carotenoids can be fulfilled. These carotenoids are involved in the reduction of free radicals that helps to promote health

with boosting the immune system and strengthening endocrine system.

After digestion of food containing carotenoids are absorbed with fat soluble molecules in the small intestine and then transferred to the liver. Liver converts these carotenoids into very low density lipoproteins (VLDL). Lipase enzymes in the liver changes VLDL into different lipoprotein molecules and as a result of this metabolism, high-density lipoproteins (HDL) and low-density lipoproteins (LDL) are formed, which then transferred to the peripheral tissues. There is still an ambiguity that how much carotenoids are metabolized in liver and how much is converted into other forms. Different components of diet affect the absorption of carotenoids. Among these factors, genetics, sex, hormonal status, age, and are mainly influence the absorption of carotenoids. These all factors are interrelated with each other and their degree of influence on the absorption of carotenoids is still unknown [11-15].

### Sources of carotenoids

Carotenoids availability and type can be guessed by their color, e.g.,  $\alpha$ -carotene and  $\beta$ -carotene found to be rich in yellow-orange fruits and vegetables. Zeinoxanthin and  $\alpha$ -cryptoxanthin produced in orange fruits, e.g., papaya, mandarin and orange. Likewise, lycopene is main component of tomatoes, grapefruit and watermelon with bright red color. Lutein (about 45%),  $\beta$ -carotene (about 25-30%), neoxanthin (10-15%) and violaxanthin

(10-15%) are present in green leafy vegetable.  $\alpha$ -carotene, lutein, antheraxanthin, zeaxanthin,  $\beta$ -cryptoxanthin are also found in green leafy vegetables in small amounts. Usually,  $\beta$ -carotene is more in concentrations to its geometric isomer,  $\alpha$ -carotene in many vegetables and fruits (Table 1).

Bioactive compounds and carotenoids are rich in traditional and non-traditional tropical fruits, which show favorable standpoints for the use of fruit species and by-products of these spices in potential products. Recently, many leafy vegetables, like *Lactuca indica*, *Moringa oleifera* and *Oenanthe javanica* were proven as extraordinary sources of carotenoids. In a study of Thai vegetables, concentrated amount of lutein and  $\beta$ -carotene were documented in *O. javanica* and *L. indica*, correspondingly. Trees for Life and Educational Concerns for Hunger Organization (International non-governmental organizations) have dynamically assisted Moringa leaves as "natural nutrition for the tropics". Citrus fruits and paprika vegetables contain little amounts of apocarotenoids. In pulps of citrus species 2–7% red apocarotenoids and  $\beta$ -citraurin has been found documented 1.5% of  $\beta$ -apocarotenoids to the total  $\beta$ -carotene existing in Orange Dew (*Cucumis melo*) and cantaloupe (*Cucumis melo*) [16-20].

Richest source of carotenoids from plants is aril of ripened fruits or seed pulp of *Momordica cochinchinensis* (common name gac fruit) recorded  $\beta$ -carotene and lycopene are the main carotenoids present in gac fruit, which have 408  $\mu\text{g/g}$  and 83.3  $\mu\text{g/g}$  fresh weigh, correspondingly. The carotenoids (major and minor) quantified from fruits of Amazonia region, that include tucuma (*Astrocaryum aculeatum*), icludes buriti (*Mauritia vinifera*), peach palm, mamey (*Mammea americana*), physalis (*Physalis angulata*) and marimari (*Geoffrola striata*). As a result, a total of 60 different carotenoids were recognized, the total carotenoid concentration fall between 38  $\mu\text{g/g}$  in marimari to 514  $\mu\text{g/g}$  in buriti, between these, all-E- $\beta$ -carotene was the main carotenoid in all foods. The maximum concentration of  $\beta$ -carotene was present in Acerola pulp (26.23  $\mu\text{g/g}$ ), then in papaya (20.24  $\mu\text{g/g}$ ) followed by Surinam cherry (15.64  $\mu\text{g/g}$ ) pulp on dry weight basis.

### Bioavailability and metabolism of carotenoids in human body

Bioavailability is the amount of carotenoid absorbed in body as a systematic circulation and available for usage in physiological functions and storage in human body. There are several factors affecting the digestion, absorption, movement and storage of carotenoids. Sometime crystallization of carotenoids decreases their availability. It is had been observed that only 5% of carotenoids are absorbed in the intestine and remaining is present in micellar solution. Investigations showed that thermal treatment increases the availability of carotenoids due to disturbance of cell walls and bond loosening. Carotenoids bioavailability can also be determined by other factors including gender, infection, nutritional status, ageing and genetic factors. It is established that several sicknesses with the odd absorption of lipids form the gastrointestinal tract considerably disturbs carotenoids incorporation. Moreover, the accessibility of  $\beta$ -carotene was revealed to decrease when interaction of drugs such as aspirin or sulfonamides occur.

Generally, carotenoids are derived through biosynthesis of isoprenoid in conjunction with a range of some other naturally producing substances for example gibberellic acid and steroids. Mevalonic acid is the preliminary produce requisite to synthesize all isoprene derivatives which upon phosphorylation converted into a phosphorylated isoprene. This isoprene consequently polymerises. In the sequence of polymerization, the position and number of the double bonds are fixed. Biosynthesis and deprivation of xanthophylls, carotenes, carotenogenesis regulation, in addition functions of these components, have been described very well in plants, animals and humans. For adult men RDA of carotenoids is 1000 RE, for adult and pregnant women 800 RE and 1300 RE for lactating women reported the metabolism of carotenoids through multi-gene engineering. Two molecules of geranylgeranyl pyrophosphate converts into phytoene (40-carbon intermediate in the biosynthesis of all carotenoids) components, this initial reaction is particular to carotenoids type of isoprenoid metabolism. From this phase, little unusual reactions might be set up in various organisms. Respectively, fungi, anoxygenic photosynthetic bacteria, non-photosynthetic bacteria desaturate phytoene in three to four times to form lycopene or neurosporene. Comparatively, phytoene converts into lycopene through carotene in two individual groups of reactions by oxygenic photosynthetic organisms. At the level of lycopene or neurosporene, the carotenoid biosynthesis through different pathways to produce the enormous varieties of carotenoids originate in nature [21-25].

The bacterio-chlorophyll and lipophilic carotenoid or chlorophyll pigment molecules connect non-covalently, however precisely through integral membrane proteins in photosynthetic organisms. Carotenoids are protein bounded in non-photosynthetic organisms and tissues; take place in cell wall or cytoplasmic membranes, fibrils, oil droplets and crystals. As animals and humans have no ability to synthesize carotenoids *de novo*. To combat the requirement carotenoids must be taken through diet. Most of the carotenoids which are taken through diet absorbed through mucosal cells in gastrointestinal tract

**Table 1** Sources of main carotenoids with their pro-vitamin A and non-provitamin A [9].

Class of carotenoid	Example	Main sources
Pro-vitamin A	$\beta$ -Carotene	Celery, tomatoes, spinach, lattice, carrot, broccoli and parsley.
	$\alpha$ -Carotene	Green leafy vegetables.
	$\beta$ -Cryptoxanthin	Papayas, peaches, mangoes and oranges.
Non-provitamin A	Lutein	Green leafy vegetables kale, spinach, Broccoli, parsley, beans, corn, avocado and Brussels sprouts.
	Lycopene	Tomatoes, papaya, grapefruit and water melon.
	Zeaxanthin	Kale, spinach, broccoli, parsley, beans, corn, avocado, mandarins, peaches and oranges.

and remain unchanged in tissues and during circulation have been well described in human beings. Through passive diffusion carotenoids are absorbed in intestine after being integrated with micelles which are produced through bile acids and dietary fat. Then these micellar carotenoids are integrated with chylomicrons and distributed into the lymphatic system. Exclusively, lipoprotein carotenoids are delivered in the plasma. Carotenoids that have oxygen functionality are relatively have additional polar in nature than those which have no functionality. That's why; lycopene,  $\alpha$ -carotene and  $\beta$ -carotene have a tendency to fall in low-density lipoproteins in the circulation, while xanthophylls for example lutein, zeaxanthin and cryptoxanthins fall into high-density lipoproteins. By the integration of lipoprotein molecules with receptors the transportation of carotenoids to extra hepatic tissues and the degradation takes place through lipoprotein lipase [26-34].

Though more than forty carotenoids are generally taken through food intake, just six of them and metabolites of these carotenoids have been observed in human tissues and organs. In breast milk of lactating mother's thirty-four carotenoids and eight metabolites are observed. Mainly absorption of these carotenoids occur in intestine, facilitated diffusion has been found additionally to simple diffusion intercede the absorption of carotenoids in intestine of mammals. The absorption of carotenoids might be because of uptake to intestinal epithelia through facilitated diffusion and an unfamiliar process of secretion into the intestinal lumen [35-39].

Transformation of  $\beta$ -carotene into vitamin A in intestines is very well demonstrated but the metabolic conversion of xanthophylls is little demonstrated in literature. Secondary hydroxyl group through enzymatic oxidation leads to keto-carotenoids that act as a communal pathway of metabolism of xanthophylls in living organisms.

### Biological functions and benefits

In those organisms that make carbohydrates from carbon dioxide and water by using sun light as energy, they include carotenoids, microalgae and plants play numerous functions. Essentially, carotenoids are likely to work as an assisting pigment in light mowing functions through the light phase of photosynthesis and also have ability to photo guard the photosynthetic machinery from extra light by scavenging reactive oxygen species such as free radicals and singlet oxygen.

Because of their biotechnological applications and beneficial effects to human these pigments have gained a considerable attention. The antioxidant properties which are mostly related to their biological purposes of carotenoids in human beings are directly arising from their molecular structure. In later years, the exploration for appropriate stratagems and the envisage of reactive oxygen species -convinced oxidative stress mechanisms to combat oxidative stress has turn out to be one of the chief goal line of medical researchers. Many of the studies have been stated that associate oxidative stress contributing degenerative pathogenesis, for example Alzheimer and Parkinson. In correspondence to lessen the hazard of suffering from

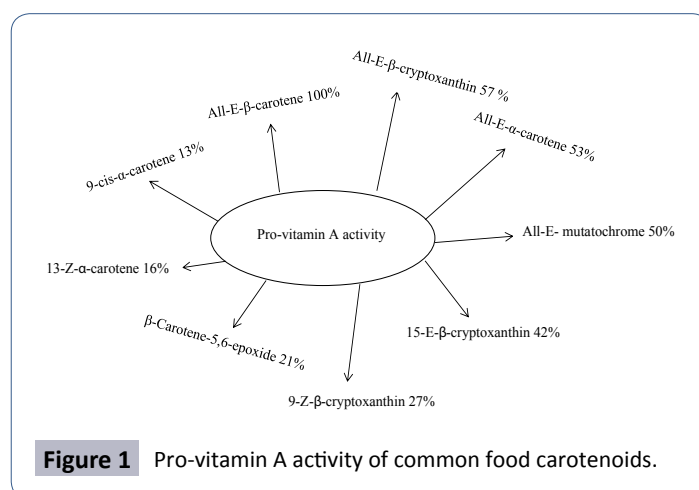
degenerative disorder a carotenoid supplemented diet has been found to be active to lesser the effects.

However, the beneficial effects of carotenoids to human beings have been constructed upon the productive influences of the antioxidant activity of carotenoids in signaling transduction among cells, anti-inflammatory reaction mechanisms and also in immuno-response modulation (Schwarz, 2008). These constructive concerns are the outcome of either through countenance of various genes tangled in antioxidant responses or the straight chemical exploit of carotenoids on biological structures and molecules.

### Carotenoids biological functions and benefits to health are described as follows

**Vitamin A activity:** Among 700 founded carotenoids nearly 50 are verified for their pro-vitamin A activity (Hurst, 2008). Carotenoids show their pro-vitamin A activity by the action of an enzyme (carotene dioxygenase) which converts carotenoids into vitamin A in the form of retinol and retinal. Carotenoid having minimally one unmodified  $\beta$ -ionone ring possibly cleaved to deliver pro-vitamin A activity. As a result, pro-vitamin A active carotenoids contain  $\alpha$ -carotene,  $\beta$ -carotene,  $\gamma$ -carotene, and  $\beta$ -cryptoxanthin.  $\beta$ -carotene comprises two  $\beta$ -ionone ring, thus it owns 100% pro-vitamin A activity, and lycopene deficient in pro-vitamin A activity because of the lack of  $\beta$ -ionone ring. Pro-vitamin A activity of main carotenoids is showed in **Figure 1**.

Fundamentally, retinol is one half of the molecule of  $\beta$ -carotene by means of an added molecule of water. Though pro-vitamin A activity is the main role of carotenoids, effective antioxidant activity of carotenoids through singlet oxygen quenching and deactivation of free radicals shows significant functions in the inhibition of various forms of cancer, macular degeneration, cardiovascular diseases and eye related disorders (**Figure 1**). It revealed that in small intestinal lumen, carotenes can be transmuted into vitamin A mostly in the form of retinyl ester (20-75%) by splitting of carotene molecule. As the major transformation of carotenoid molecule into vitamin A occur in the intestinal mucosa. The synthetic  $\beta$ -carotene has 50% of the potency of retinol; in other words, 2 mg  $\beta$ -carotene is equivalent to 1 mg vitamin A. Although,  $\beta$ -carotenoids cannot show to



**Figure 1** Pro-vitamin A activity of common food carotenoids.

cause vitamin A toxicity, it has been verified in various species that once dietetic  $\beta$ -carotene rises, the balancing process control vitamin A formation from carotenoids.

**Cancer:** According to World Health Organization, cancer is the second leading cause of deaths globally and deaths due to tumors was 8.8 million in 2015. Nearly 1 out of 6 deaths are due to cancer. Therefore, there is a dire need to take some tolerable steps to lessen and amend the factors distressing the danger of cancer. Obviously, one of the simplest step appears in mind is ample intake of organic foods that are crowded in biologically active complexes.

Numerous prospective studies have displayed a constructive relationship among the ingestion of carotenoids-rich foods and a reduced hazard of different kinds of cancer. A large assemblage of data on lungs cancer and dietary carotenoids has been brought to door step. The results usually up keep the observation of morbidity upon  $\beta$ -carotene supplementation in non-smoking adults. Therefore, many studies of carotenoids diet and lung cancer on non-smokers established, a contrary correlation found between lung cancer risk and ingestions of food sources rich in carotenoids. These depictions were proven by the  $\beta$ -carotene and Retinol Efficacy Trial (CARET) study, where mixture of vitamin A supplementation and  $\beta$ -carotene was trialed between men and women at a high risk of increasing lung cancer (smokers and asbestos workers) and in subjects those who intake larger quantities of alcohol. So far, from thorough scrutinization of the consequences, it determines that the unpredicted "cancerogenic" properties of carotenoids supplementation may be defined in relations of their strong intervention with the lifestyle disorders of the individuals. From the data on studies of prostate cancer support the concept that various carotenoids and carotenoid-rich food might be involved in the inhibition of the risk of prostate cancer.

Among carotenoids, lycopene is considered as the most potent agent against tumor. The preclinical studies summarize multiple possible ways of lycopene action, claiming, at the same time, its importance in the enrichment of the oxidation stress defense system. Further investigations supporting the mentioned studies have been taken from meta-analysis of the observational studies on the role of lycopene and tomato products in the hindrance of prostate cancer and lungs cancer.

The human study trials documented  $\beta$ -carotene as a prominent source in the hindrance of larynx, oral and pharynx cancers. This data provide convention with other opinions that taking large amounts of food containing carotenoids outcomes in the inhibition of risk of oral and throat cancers about 50%, reported same data in the case of esophageal cancer. In numerous case-control studies, it has been found that high ingestion of fruits and vegetables lead to 40%-50% lesser risk of this form of cancer in relations to low intakes. Moreover, a huge figure of confirmation shows a correlation among the consumption of fruits and vegetables and the risk for colon cancer development. Correspondingly, the case-control studies approve the negative relation among fruits/vegetable consumption, serum concentration of carotenoids and colon cancer risk [40-44].

**Cardiovascular diseases:** Cardiac health issues are one of the primary causes of death in the world. Cardiac disorders consist of severe heart attack and disorder of high mortality and morbidity. Oxidative stress and inflammation are one of the factors for cardiac disorders. In oxidative stress, the reactive oxygen species can lead to oxidation of low density lipoproteins that plays an important role in pathogenicity of atherosclerosis.

Carotenoids play a significant role in the protection of low density lipoproteins from oxidation that shows anti-atherogenic properties of carotenoids. Furthermore, in vivo studies it have been revealed that carotenoids inhibit lipid peroxidation mechanisms by which the presence of carotenoids in cell membranes play as crucial role to act as alleviating elements of these structures. Investigated antioxidant properties of these compounds during radical peroxide-induced cholesterol *that* shows that they exerted a prominent antioxidant activity, in descending order it showed: astaxanthin, cantaxanthin, lutein and  $\beta$ -carotene. Daily supplementation of  $\beta$ -carotene to animals shows decreased plasma levels of total lipids, triglycerides and cholesterol.

Similarly, low levels of  $\alpha$ -carotene in serum shows reverse relation in occurrence of coronary artery disorder and development of arterial plaque, through which  $\alpha$ -carotene projected as a potential marker for atherosclerosis in human. Moreover, carotenoids those possess higher levels of provitamin A activities have ability to reduce hazards of angina pectoris disease. The higher levels of lutein and  $\beta$ -cryptoxanthin in plasma have shown lower hazard of cardiac infraction for those people suffering from cardiac disorders.

**Vision health:** Various studies demonstrated that zeaxanthin and lutein are major pigments that are responsible for maintenance of normal visual functioning and yellowing of the humanoid eye macula. Whereas major carotenoids are absent or found in very minute quantities in the human macula which includes  $\alpha$ -carotene,  $\beta$ -carotene,  $\beta$ -cryptoxanthin and lycopene. Zeaxanthin and lutein in the eye macula absorbs blue light and diminish pernicious photo-oxidative effects due to extra blue light whereas decreasing eye chromatic aberration. Carotenoids have ability to protect eye macula from adversative photochemical reactions because they have antioxidant properties. Visual sensitivity greatly depends on zeaxanthin and lutein concentration in retina of people over the age of 64. People with lower levels of zeaxanthin and lutein linked with the problem of cataracts. Also the lower levels of zeaxanthin and lutein become the source of macular degeneration which is the major cause of permanent loss of eye sight in people more than the age of 65 in developed countries.

Zeaxanthin and lutein spectrum indicates a large absorption band with a peak at 450 nm that is assumed to be participate in absorbing extra blue light beforehand it approaches to photoreceptors, so it prevents the eye macula from being impaired by blue light. Furthermore, the physic-chemical and biological properties of both carotenoids possess to save the membrane structure in the eye photoreceptors because of their reactive oxygen scavenging properties, in contrast to other non-polar carotenoids as  $\beta$ -carotene and lycopene.

**Immunity response:** Both in vivo and vitro laboratory studies have been confirmed that  $\beta$ - carotene have ability to protect phagocytic cells from auto-oxidative impairment, encourage effector T cell functions, boost T and B lymphocyte proliferative responses, enhances the formation of various interleukins and increases macrophage, along with natural killer cell tumoricidal capacities and cytotoxic T cell. Recent studies have shown that lesser serum concentrations of lycopene,  $\alpha$ -carotene and  $\beta$ -carotene reported in HIV affected women, particularly in those who have lower counts of CD-4 helper cells. In HIV and AIDS patients both  $\beta$ -carotene and selenium are inadequate in a significant percentage. They act as antioxidants in both HIV and AIDS conditions seem to be associated to inhibition of cytokine, NF-kB activation, inhibiting HIV replication and direct immune modulation.  $\beta$ -carotene has been exposed to act as an immune modulator by enhancing CD4 count and encouraging natural killer cell function.  $\beta$ -carotene as an antioxidant seems to maintain enzymatic defence system connected in diminishing oxidative impairment [45-49].

**Photosensitivity disorders:** Carotenoids have ability to provide skin photo protection against UV light. They also hold anti-inflammatory effects because of their scavenging action on reactive oxygen species. Due to these properties, recently it has been reported that astaxanthin promotes anti-inflammatory properties that maintains vital proteins and lipids of human lymphocytes. Astaxanthin act by persuading catalase enzyme and superoxide dismutase activities. Some further researches have revealed astaxanthin to shield from CCl4-induced hepatic impairment by hindering lipid peroxidation, appealing modulating the inflammatory process and cellular antioxidant system. **Table 2** shows biological functions and medicinal properties of carotenoids, containing their role in retinitis, hindrance of cataracts, macular degeneration, and gastric infection.

Another property of carotenoids is to act as a preservative that has been used in cosmetics and food products, joined with some other algal bioactive elements or antioxidants, also in lotions and cream for sun protection. The advantageous influence of carotenoids has also been exposed in patients with skin inflammatory pathology and psoriasis. Lima and demonstrated minor levels of carotenoids in the skin associate well with psoriasis incidence.

On the last but not least, the interesting thing to note that carotenoids are also plays a significant role in gastric diseases. In studies it has been demonstrated that higher consumption of carotenoids inhibits the expansion of conditions affected by *Helicobacter pylori*, a Gram negative bacteria class that inhabits the gastric mucosa as a minimum half of the human population [50-54].

**Carotenoids as fortified substances in food industry:** There is an extra task to use carotenoids as ingredients in functional foods as they have high melting point, which make crystals during food storage. In spite of that, endogenous carotenoids in foods are generally stable. Though, carotenoids as food additives are comparatively unpredictable in food systems because they are vulnerable to auto-oxidation, light and oxygen. Mixing of carotenoids with other food material their properties can be diminished. Because of the loss of double bond carotenoids might be degraded by reactions. Additionally, there will be cis configuration when double bonds in carotenoids undertake isomerization and revealed that isomerization reactions might be valuable due to cis isomers of carotenoids for example lycopene are assumed to be more bioactive and bioavailable and reported that carotenoids are utilized by the industry as colorants in numerous food supplements and drinks. In collective studies carotenoids have been stated to act as chain breaking

**Table 2** Biological functions and medicinal properties of carotenoids, containing their role in retinitis, hindrance of cataracts, macular degeneration and gastric infection.

Main carotenoids	Biological function and medicinal properties
Astaxanthin	In liver, prostate tumors and benign prostatic hyperplasia Inflammatory inhibition properties
$\beta$ -carotene	Pro-vitamin A function In the prevention of acute and chronic coronary syndromes In colorectal cancer Photo-protection of body skin alongside UV light
Lycopene	In prostate cancer and prostatic hyperplasia In the hindrance of acute and chronic coronary syndromes and atherosclerosis
Zeaxanthin	Helps to maintain a normal visual function In the hindrance of acute and chronic coronary syndromes Active against liver neoplasms In the hindrance of cataracts To inhibit macular disintegration linked with age
Lutein	In hindrance of stroke, acute and chronic coronary syndromes In the hindrance of cataracts Aids to uphold a typical visual function To inhibit macular disintegration linked with age To escape gastric infection by <i>H. Pylori</i> In the hindrance of retinitis

antioxidants beneath specific conditions. However due to their highly conjugated structure, carotenoids are very unstable and can be easily degraded when exposed to oxygen or light during storage or manufacturing of foods. Because of that there may be a loss of their desirable biological and nutritive properties in addition to the formation of objectionable flavor or aroma components. Because of these reasons, these components are not generally handled in their crystalline form but relatively as encapsulated forms. Encapsulation of carotenoids ( $\alpha$ -carotene) is carried out which has generated a prospect for the production of carotenoid ( $\alpha$ -carotene) forms for food fortification and supplementation. For encapsulating lipophilic functional compounds such as bioactive lipids and flavors, simple oil-in-water emulsions are presently the most extensively used technique. The potential for using multiple emulsions to encapsulate some lipophilic nutraceutical components or functional food has been confirmed, like  $\alpha$ -carotene. Due to that there is a solid reason for using carotenoids as functional ingredients in food commodities. Conversely,  $\beta$ -carotene is weakly soluble in oil and insoluble in water at ambient temperature due to its crystalline form, therefore making it difficult to integrate in food commodities.

Moreover,  $\beta$ -carotene is sensitive to heat, light and oxygen that limit its applications in the food industry (**Table 2**).

From days, nanotechnology rapidly occurred as one of the best encouraging research fields, with applications in health industries reported that food industry could have benefits from nanotechnology applications because this technology has potential to enhance solubility and bioavailability of different functional ingredients such as the "carotenoids" [55-60].

## Conclusion

Carotenoids are natural pigments. While providing coloring property, additionally, these compounds exhibit health promoting effects on consumer health. In fact, carotenoids show the property of antioxidants, directly involved in the mechanism of scavenging the free radicals. Literature had demonstrated the high impact of carotenoids on different life style related disorders, including, cardiovascular diseases and cancer. The antioxidant property of carotenoids is the key involved in the prevention of all disorders. Moreover, the exact mechanism and target doze for particular disease is yet to be explored.

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