



## **Role of Carotenoids in Human Health**

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### **Abstract**

Carotenoids are naturally occurring pigments responsible for the vibrant yellow, orange, and red colors of many fruits and vegetables. Beyond their role in plant physiology, carotenoids have significant importance in human nutrition and health. These compounds function as antioxidants, support immune function, promote eye health, and reduce the risk of chronic diseases such as cardiovascular disorders and certain cancers. Some carotenoids, such as  $\beta$ -carotene, also serve as precursors of vitamin A, an essential nutrient for vision, growth, and immune competence. Increasing scientific evidence highlights the protective role of carotenoid-rich diets in preventing oxidative stress and inflammation-related diseases. This article discusses the classification, sources, biological functions, and health benefits of carotenoids, emphasizing their crucial role in maintaining overall well-being.

### **Introduction**

Carotenoids are a class of fat-soluble pigments synthesized by plants, algae, and photosynthetic bacteria. More than 700 carotenoids have been identified in nature, but about 40 are commonly found in the human diet. Among these,  $\beta$ -carotene,  $\alpha$ -carotene, lycopene, lutein, and zeaxanthin are the most studied for their health benefits.

Humans cannot synthesize carotenoids; therefore, they must be obtained through dietary sources such as carrots, tomatoes, spinach, mangoes, papaya, pumpkin, and marigold petals. In plants, carotenoids play a crucial role in photosynthesis and protection against photooxidative damage. In humans, they act primarily as antioxidants and vitamin A precursors, contributing significantly to disease prevention and health promotion.



In recent decades, growing awareness of lifestyle-related diseases has increased interest in the role of dietary antioxidants, especially carotenoids, in promoting long-term health.

### **Classification of Carotenoids**

Carotenoids are broadly classified into two main groups:

1. **Carotenes** – Hydrocarbon carotenoids (e.g.,  $\beta$ -carotene,  $\alpha$ -carotene, lycopene).
2. **Xanthophylls** – Oxygen-containing carotenoids (e.g., lutein, zeaxanthin, astaxanthin).

Some carotenoids ( $\beta$ -carotene,  $\alpha$ -carotene, and  $\beta$ -cryptoxanthin) are known as **provitamin A carotenoids** because they can be converted into retinol (vitamin A) in the human body.

### **Dietary Sources of Carotenoids**

Carotenoids are abundant in colorful fruits and vegetables:

- **$\beta$ -carotene** – Carrot, sweet potato, pumpkin, mango
- **Lycopene** – Tomato, watermelon, guava
- **Lutein and Zeaxanthin** – Spinach, kale, corn, marigold petals
- **$\beta$ -cryptoxanthin** – Papaya, orange, red pepper

Dark green leafy vegetables are particularly rich in lutein and zeaxanthin, while red fruits are rich in lycopene. A balanced diet rich in plant-based foods ensures adequate carotenoid intake.

### **Role of Carotenoids in Human Health**

#### **1. Antioxidant Activity**

Carotenoids are powerful antioxidants that neutralize free radicals and reactive oxygen species (ROS). Oxidative stress is implicated in aging and chronic diseases such as cancer, cardiovascular diseases, and neurodegenerative disorders. Lycopene and  $\beta$ -carotene are particularly effective in scavenging singlet oxygen and preventing lipid peroxidation.

According to scientific studies, higher plasma carotenoid levels are associated with reduced markers of oxidative stress and inflammation.

#### **2. Role in Eye Health**



Lutein and zeaxanthin are concentrated in the macula of the retina, where they form the macular pigment. They protect the eye by:

- Filtering harmful blue light
- Reducing oxidative damage
- Lowering the risk of age-related macular degeneration (AMD)

The Age-Related Eye Disease Study 2 (AREDS2) demonstrated that supplementation with lutein and zeaxanthin reduced the progression of AMD.

### **3. Immune System Support**

Vitamin A derived from provitamin A carotenoids plays a crucial role in immune function. It maintains the integrity of mucosal barriers and supports the production of white blood cells. Deficiency in vitamin A can increase susceptibility to infections.

Carotenoids also modulate immune responses through their antioxidant and anti-inflammatory effects.

### **4. Cardiovascular Health**

Carotenoids help reduce the risk of cardiovascular diseases by:

- Decreasing LDL oxidation
- Reducing inflammation
- Improving endothelial function

Studies suggest that higher dietary intake of lycopene is associated with lower risk of coronary heart disease and stroke.

### **5. Cancer Prevention**

Epidemiological studies indicate that diets rich in carotenoid-containing fruits and vegetables are associated with a lower risk of certain cancers, including lung, prostate, and breast cancers. Lycopene has been extensively studied for its protective effect against prostate cancer.

However, high-dose  $\beta$ -carotene supplementation in smokers has been linked to increased lung



cancer risk, highlighting the importance of obtaining carotenoids from natural food sources rather than excessive supplements.

## **6. Skin Protection**

Carotenoids accumulate in the skin and provide protection against ultraviolet (UV) radiation-induced damage.  $\beta$ -carotene and lycopene improve skin appearance and reduce sensitivity to sunburn by acting as internal photoprotective agents.

## **7. Role in Cognitive Health**

Emerging research suggests that carotenoids may help protect against cognitive decline. Lutein and zeaxanthin are found in brain tissue and are believed to support memory and cognitive performance through antioxidant mechanisms.

## **Bioavailability of Carotenoids**

Carotenoids are fat-soluble; therefore, their absorption improves when consumed with dietary fats. Cooking and processing (such as making tomato paste) can increase the bioavailability of certain carotenoids like lycopene.

## **Conclusion**

Carotenoids play a multifaceted role in human health. From acting as powerful antioxidants to supporting vision, immunity, cardiovascular health, skin protection, and possibly cognitive function, these natural pigments are essential components of a healthy diet. The most effective way to obtain carotenoids is through regular consumption of a diverse range of colorful fruits and vegetables. Rather than relying on supplements, adopting a balanced plant-rich diet ensures optimal intake and synergistic health benefits. Continued research further strengthens the evidence that carotenoids are vital dietary compounds contributing to disease prevention and overall well-being.

## **References**

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