



Lutein and Zeaxanthin: Health-Friendly Nutrients

Sağlık Dostu Besin Bileşenleri: Lutein ve Zeaksantin

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Abstract

Carotenoids are essential fat-soluble nutrients that are important components of a healthy diet. Among the carotenoids, lutein and zeaxanthin are the two most abundant carotenoids found in the diet. Humans cannot synthesize lutein or zeaxanthin de novo; therefore, the diet is the sole source of these compounds in the human body. These two carotenoids are present in high amounts in green leafy vegetables and in chicken egg yolk. Lutein and zeaxanthin are also found in the free form in spinach and broccoli; as esters in mango, orange, papaya, red paprika, algae, and yellow corn. The macula of the eye is a repository for these two carotenoids. A higher dietary intake of lutein and zeaxanthin has shown to reduce the risk of cataracts and age-related macular degeneration. Lutein and zeaxanthin inhibit lipid peroxidation, a likely factor in the etiology of both retinal and cardiovascular disease. It has long been thought that carotenoid intake also reduces the risk of certain forms of cardiovascular disease, stroke, and cancer. Skin exposure to UV rays generates reactive oxygen species, inflammation in skin cells, and erythema. Lutein and zeaxanthin may prevent cellular damage in these conditions by quenching singlet oxygen or neutralizing photosensitizers.

The purpose of this article is the scientific literature pertaining to review characteristics, mechanisms of action and food sources of lutein and zeaxanthin, which are related to the health.

Keywords: Carotenoid, Health, Lutein, Zeaxanthin

Öz

Karotenoidler, sağlıklı bir diyetin önemli bileşenleri olan yağda çözünen besin maddeleridir. Karotenoidler arasında, lutein ve zeaksantin, diyetten en fazla bulunan karotenoidlerden ikisidir. İnsanlar lutein veya zeaksantin bileşiklerini de novo şartlarda sentezleyememekte, bu nedenle diyet, insan vücudunda bu bileşiklerin tek kaynağı olarak yer almaktadır. Bu iki karotenoid yeşil yapraklı sebzelerde ve tavuk yumurtası sarısında yüksek miktarlarda bulunmaktadır. Aynı zamanda, lutein ve zeaksantin, ıspanak ve brokolide serbest formda; mango, portakal, papaya, kırmızı biber, yosun ve sarı mısırdaki ise ester formunda bulunmaktadır. Göz makula yapısı, bu iki karotenoid için bir depodur. Lutein ve zeaksantin bir diyetten daha fazla alınmasının katarakt riskini ve yaşa bağlı makula dejenerasyonu riskini azalttığını göstermiştir. Lutein ve zeaksantin hem retinal hem de kardiyovasküler hastalığın etiyolojisinde muhtemel bir faktör olan lipid peroksidasyonunu inhibe etmektedir. Aynı zamanda uzun süreli karotenoid alımının bazı kardiyovasküler hastalık, inme ve kanser riskini azalttığı düşünülmektedir. Cildin UV ışınlarına maruz kalması; reaktif oksijen türlerini, deri hücrelerinde iltihaplanmayı ve iltihaplanmaya bağlı kızarıklıkları oluşturmaktadır. Lutein ve zeaksantin, bu koşullardaki tekli oksijen veya nötralize edici fotosensitizörleri söndürerek hücre hasarını önleyebilmektedir.

Bu makalenin amacı, sağlıkla ilişkili olarak lutein ve zeaksantin'in besin kaynaklarına, etki mekanizmalarına ve karakteristik özelliklerine ilişkin bilimsel literatürü içermektedir.

Anahtar Kelimeler: Karotenoid, Sağlık, Lutein, Zeaksantin

1. Introduction

Carotenoids are lipophilic pigments that provide many of the colors found in nature as a result of their light-absorption characteristics. This includes the colors found

in plants, flowers, and animals. Carotenoids can be grouped into several subclassifications, with the most familiar being the provitamin A carotenoids (those that can be converted to vitamin A in the human body) and the non-provitamin A carotenoids (those that cannot be converted to vitamin A in the human body). Lutein and zeaxanthin belong to the subclass of non-provitamin A carotenoids known as the xanthophylls. Xanthophylls are also different from other

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carotenoids because they contain oxygenated substituents. Although xanthophylls have significant structural similarities to other carotenoid compounds, such as beta-carotene, they specifically have free hydroxyl groups at each end of the molecule that provide unique biochemical properties. These hydroxyl groups are responsible for the characteristics of lutein and zeaxanthin that allow them to orient within cell membranes and lipoproteins in ways other carotenoids cannot (Goulinet and Chapman 1997, Sujak et al. 2000). The xanthophylls lutein and zeaxanthin are plant pigments that selectively accumulate in the macula of the retina of the eye where they are thought to protect against the development of age-related macular degeneration (AMD) (Bone and Landrum 1992, Snodderly 1995). In the macula, lutein and zeaxanthin are collectively referred to as macular pigment (Bone et al. 1985, Moeller et al. 2008). The presence of lutein and zeaxanthin in human blood and tissues is entirely due to the ingestion of food sources containing these xanthophylls. The mechanisms by which lutein and zeaxanthin are thought to provide protection to the eye are through their roles as blue light filters and/or as antioxidants (Snodderly 1995).

Lutein and zeaxanthin are found in human skin as a result of dietary intake (Wingerath et al. 1998, Hata et al. 2000). In addition, these xanthophylls have been shown to help provide protection against skin damage caused by UV light in animal studies. These studies demonstrated that the ingestion of lutein and zeaxanthin helps provide protection against skin swelling (edema) and hyperplasia caused by UV exposure of the skin (González et al. 2003). Furthermore, the ingestion of these xanthophylls has been shown in animals to reduce the potential of UV light to suppress the immune functionality of the skin (Lee et al. 2004). Carotenoid intake, specifically β -carotene, lycopene, and lutein plus zeaxanthin,

showed a protective effect against 4-year loss in trochanter bone mineral density in men and lumbar spine in women (Sahni et al. 2009).

The purpose of this paper is the scientific literature pertaining to review characteristics, mechanisms of action and food sources of lutein and zeaxanthin, which are related to the health.

2. Lutein and Zeaxanthin Structure

The structure of lutein can be described as a long carbon chain with alternating single and double carbon-carbon bonds with attached methyl side groups. At both ends of the carbon backbone, the molecule contains a cyclic hexenyl structure with an attached hydroxyl group. They belong to a group of carotenoids whereby the difference in structure between lutein and zeaxanthin is due to the position of the double bonds in the hexenyl ring and the position of methyl groups on the long carbon chain (Figure 1). The presence of a hydroxyl group at both ends of the molecule distinguishes lutein and zeaxanthin from other carotenoids. The characteristic structure with nine double bonds is responsible for the absorbance of certain wavelengths of light and the emission of other wavelengths leading to the characteristic colour properties of these molecules. In view of its blue light absorption, lutein has a yellow or orange like appearance depending on its concentration (Kijlstra et al. 2012, Nwachukwu et al. 2016).

3. Dietary Intakes

In the diet, dark green leafy vegetables, corn, and egg yolk contain the highest concentrations of lutein. Zeaxanthin is found in corn, orange pepper, oranges, and tangerines (Sommerburg et al. 1998, Perry et al. 2009). Lutein and

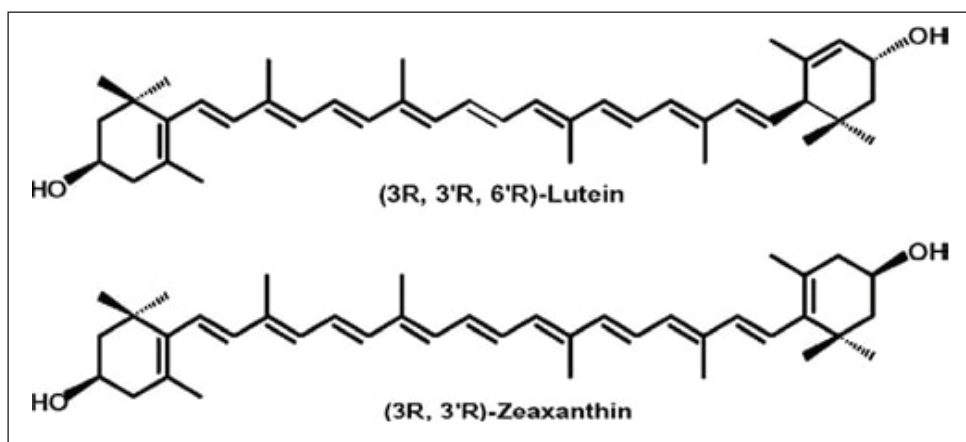


Figure 1. Structures of lutein and zeaxanthin (Roberts et al. 2009).

zeaxanthin typically occur together in many yellow fruits and vegetables, leafy green vegetables, and egg yolks. Of the 2, lutein is more dominant, with most fruits and vegetables containing 7 to 10 times more lutein than zeaxanthin. Rare exceptions are oranges and orange peppers, which contain more zeaxanthin than lutein. Xanthophylls are used in chicken feed by the poultry industry to enhance the color of egg yolks, and eggs are a highly bioavailable source of both compounds. Zeaxanthin is predominantly supplied by corn tortillas, eggs and orange juice (Johnson et al. 2010). The dietary intake of carotenoids varies widely between individuals, and epidemiological studies have consistently shown that all age groups and ethnicities, as well as both sexes, have overall greater lutein than zeaxanthin consumption (Johnson et al. 2010, Bernstein et al. 2016). As measured in a number of epidemiological studies, the average diet in the United States contains approximately 1-3 mg of lutein and zeaxanthin combined, with a wide range of variability (Brown et al. 1999, Tucker et al. 1999) A study reported even lower levels, with average daily intakes of 0.78-1.13 mg/day of lutein and zeaxanthin among adults age 19 and over (Johnson et al. 2010). The bioavailability of lutein and zeaxanthin is affected by the source, method of preparation and presence of other carotenoids, as well as individual physiological factors. Epidemiological evidence suggests potential protection from age-related eye disease at an intake of about 6 mg or more per day of lutein and zeaxanthin from food (Seddon et al. 1994). There have not been any epidemiological studies of a specific relationship between lutein and zeaxanthin intake and visual performance; however, higher macular pigment optical density (MPOD), which may be considered a marker for lutein and zeaxanthin intake, has been associated with the improved aspects of visual function ensuing from supplemental intakes of 10-20 mg of lutein and/or 2-20 mg zeaxanthin (Hammond et al. 2001, Roberts et al. 2009, Yao et al. 2013, Bovier and Hammond 2015). An intake of 6 to 12 mg of combined lutein and zeaxanthin per day would seem as an appropriate target. It is possible to meet this target through diet alone, although comparatively few people do so. One study estimated the lutein and zeaxanthin intakes of the Third National Health and Nutrition Examination Study (NHANES III) respondents who achieved the daily servings of fruits and vegetables recommended in the Dietary Guidelines for Americans (approximately 25% of the total surveyed sample). Individuals in the 90th percentile for vegetable intake had a combined lutein and zeaxanthin intake of 7.29 mg/day; in contrast, the mean intake was

only 3.83 mg/day even among these “vegetable achievers.” (Kruger et al. 2002). Dietary supplements of lutein and zeaxanthin or multivitamin supplements with added lutein and/or zeaxanthin may help close the gap for people who are unable or unwilling to increase fruit and vegetable consumption.

4. The Effects of Lutein and Zeaxanthin on Health

Carotenoids, abundant in many fruits and vegetables, are plant derived fat-soluble pigments efficient in quenching singlet oxygen and free radicals. In vitro studies and studies in rats showed that oxidative damage to low density lipoprotein (LDL) plays an important role in the early development of atherosclerosis (Kushi et al. 1996, Dwyer et al. 2001). In the Atherosclerosis Risk in Communities (ARIC) study, there is a possible beneficial effect of a lutein-rich diet (Kritchevsky et al. 1998), which is acknowledged by the Carotid Ultrasound Disease Assessment Study (CUDAS) (McQuillan et al. 2001). The Los Angeles Atherosclerosis Study also found the inverse association between plasma lutein and early atherosclerosis, and their further study showed that higher levels of plasma lutein and zeaxanthin may be protective against early atherosclerosis (Dwyer et al. 2001, Dwyer et al. 2004). However, other epidemiological studies have reported no association between cardiovascular events and plasma or serum carotenoids (de Waart et al. 2000, Evans et al. 1998).

Many studies describe the benefits of lutein and its isomer “zeaxanthin” via oral administration or after topical application. They are able to reduce the risk of ocular diseases (Bartlett and Eperjesi 2004, Moeller et al. 2008, Beatty et al. 2013, Huang et al. 2015) and provide protective effect against cardiovascular diseases, stroke and cholesterol (Asplund 2002, Hak et al. 2004, Zou et al. 2011, Chung et al. 2017, Kishimoto et al. 2017). Oral treatment with the carotenoids lutein and zeaxanthin leads to a carotenoid deposition in the skin (Lee et al. 2004, Wu et al. 2002). Palombo et al. (2007) reported that oral and topical application of lutein is able to increase the elasticity and hydration of the skin by reducing the peroxidation process of skin lipids and increasing the superficial skin lipids.

The colour of the human macula is due to the presence of three different xanthophylls: lutein, zeaxanthin and meso-zeaxanthin (Landrum and Bone 2001). The human lens is also known to contain lutein and zeaxanthin (Berendschot et al. 2002).

In the human eyes, lutein is a macular pigment that is located in the macula lutea, which are yellow spots, between incoming photons and photoreceptors (Bone et al. 1997). Lutein has been thought to provide protection to the photoreceptors by acting as blue light filters and powerful antioxidants (Krinsky et al. 2003). It has been reported that a high serum carotenoid level and high dietary intake of lutein are associated with a lower relative risk of age-related macular degeneration (AMD) (Moeller et al. 2006). In developed countries, AMD is a leading cause of irreversible blindness in the elderly (Fine et al. 2000). The pathogenesis of AMD is not completely understood; however, there is a growing body of evidence suggesting that oxidative stress, particularly that caused by reactive oxygen species (ROS), plays an important role. This is consistent with the hypothesis that lutein prevents AMD.

5. Conclusions

Carotenoids are a class of over 600 naturally occurring phytochemical pigments synthesized by plants, algae, and photosynthetic bacteria. They are known to play a vital role in the prevention of human diseases and maintaining good health. Some of the carotenoids are used as dietary supplements, as colorants in cosmetics and foods, as animal feed additives, and in pharmaceuticals. Among the carotenoids, lutein, and zeaxanthin are the two most abundant carotenoids found in the diet. This review will provide added information to the current database for lutein and zeaxanthin.

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