The Role of Lutein in Eye Health

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Abstract

Lutein and zeaxanthin are oxycarotenoids that are naturally present in the typical human diet. They are the only two dietary carotenoids selectively deposited in the macula lutea, where they are referred to as the macular pigment (MP), and in the eye lens. The rationale for the protective role of lutein in the eye stems from its ability to filter short wavelengths of visible blue light, function as an antioxidant and stabilise membrane integrity. These functions are believed to play an important role in reducing light-induced oxidative damage caused by reactive oxygen intermediates and involved in the pathogenesis of age-related degenerative disease such as age-related macular degeneration and cataract. Recent research is now paying particular attention to the blue-light-filtering properties of lutein and zeaxanthin and to the role of MP in improving visual performance.

Keywords

Lutein, zeaxanthin, macular pigment, age-related macular degeneration (AMD), cataract, visual performance

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Lutein is a non-pro-vitamin A carotenoid pigment naturally found in plants. It exists in nature either associated with free fatty acids (lutein esters) or in free form (lutein) (see *Figure 1*). Lutein is mainly found in the leaves of plants, being an integral component of plant chloroplasts and working as an accessory pigment in the photosynthetic apparatus and as a protector against oxidative damage. Lutein esters are primarily found in the flowers or fruits of plants.[1] Most dietary lutein and its isomer zeaxanthin come from dark green leafy vegetables such as spinach, broccoli and kale as well as from eggs. It is estimated that 80% of total daily intake of these carotenoids is as lutein and 13% as zeaxanthin. Only about 7% of the lutein and zeaxanthin in the typical diet is present in the form of lutein esters and zeaxanthin esters.[2,3] Free lutein and zeaxanthin are also the only forms directly absorbed by the human body and found in the human serum. They accumulate in the retina and are the only two dietary carotenoids selectively and exclusively deposited in the macula lutea, where they are referred to as the macular pigment (MP).[4] Additionally they are the only carotenoids reported to be present in eye lens.[5]

The rationale for the protective role of lutein and zeaxanthin in the eye stems from the following abilities of these carotenoids:

- They filter harmful short-wave blue light. Lutein and zeaxanthin have a maximum absorption at 446 and 451nm, respectively.
- They function as antioxidants. These xanthophylls can act directly as antioxidants by quenching the triplet state of photosensitisers and the single state of molecular oxygen, and by scavenging radical oxygen species (ROS) and free radicals, thus limiting lipid peroxidation.[1,6]
- They stabilise membrane integrity. Thanks to the presence and orientation of the hydroxyl groups, lutein and zeaxanthin can interact with the polar head of phospholipids and span the entire width of cell membranes. Additionally, lutein has the potential to orientate parallel to the surface of the membrane.[1]

These biological functions are believed to play an important role in reducing light-induced oxidative damage caused by reactive oxygen intermediates contributing to the vascular and cellular modification involved in the pathogenesis of age-related macular degeneration (AMD).[7,8] Reactive oxygen species are also responsible for the oxidation of membrane lipids and subsequent destruction of lens proteins involved in the pathogenesis of cataracts.[9,10] Additionally, the ability of lutein and zeaxanthin to specifically filter blue light has gained importance. Recent studies have provided initial evidence about the beneficial role of the MP in visual health beyond protection against retinal degeneration.[11] The scientific evidence supporting the role of lutein and zeaxanthin in AMD, cataract and visual performance will be briefly addressed in the following sections.

Lutein and Age-related Macular Degeneration

The discovery that lutein and zeaxanthin are selectively deposited in the macula lutea, together with the fact that AMD is a degenerative disease specifically targeting this same retinal area, has prompted the scientific

community to study the relationship between lutein and zeaxanthin intake, the optical density of the MP (MPOD) and AMD.

MPOD is a measurement of the attenuation of blue light by MP and an indication of lutein and zeaxanthin concentrations in the macula. Scientific evidence from observational studies suggests that there is an inverse association between dietary lutein and zeaxanthin intake, their serum levels, MPOD, and the risk of advanced, neovascular (NV) AMD, geographic atrophy (GA) and/or presence and enlargement of drusen in human eyes.[12–16]

In a review paper published earlier in 2010,[17] a panel of experts highlighted the characteristics of the MP, addressed the value of measuring and evaluating the distribution of MPOD and concluded that AMD is in part a manifestation of an ocular deficiency of lutein and zeaxanthin. They agreed on the threshold levels for low, medium and high MPOD and, based on these levels, on the possibility of identifying people at low, medium or high risk of age-related eye diseases such as AMD.

Interventional studies confirm that supplementation for six to 12 months with 10–15mg of lutein obtained from *Tagetes erecta* (FloraGLO® lutein; see *Figure 2*) results in increased MPOD and helps to improve visual and macular function in patients suffering from AMD.[18–20]

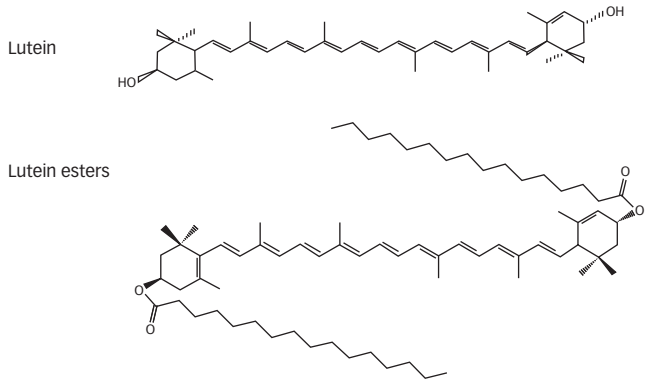
The efficacy of a nutrient-based ingredient to help reduce the progression of AMD by combining a daily dosage containing 10mg lutein (FloraGLO Lutein) and 2mg zeaxanthin alone and/or in combination with omega-3 fatty acids is currently being investigated in the Age-Related Eye Disease Study 2 (AREDS2), sponsored by the National Eye Institute in the US.[21]

Lutein and Cataract

The primary function of the lens of the eye is to collect and focus light onto the retina. To provide this function throughout life, the lens must remain clear. Accumulation of oxidised lens protein that aggregates and precipitates is believed to be the most likely mechanism behind the formation of cataract. This suggests that antioxidant nutrients may play a role in cataract risk reduction.[9,10] The positive statement issued by the French National Food Safety Agency (AFSSA) that lutein helps to protect the retina and lens from oxidation, and that it is one of the constituents of the retina and the lens, supports the relationship between lutein and cataract.[22] The results from observational studies also corroborate a protective effect of dietary intake of lutein and zeaxanthin (>6 or >10mg/day, respectively) and/or their serum levels on reducing the risk of cataracts,[23–25] although some studies have provided confounding results.[12,26]

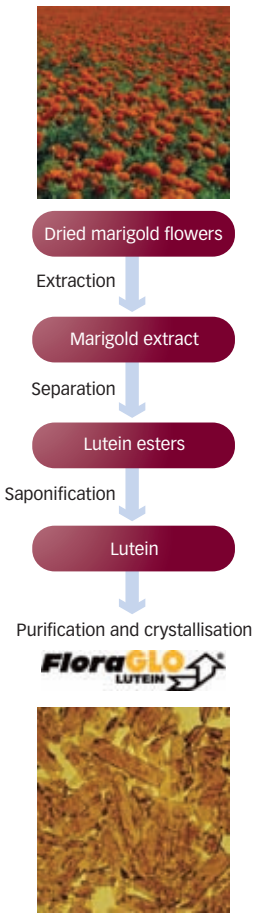
Recent evidence for the beneficial role of dietary lutein on reducing the risk of cataracts comes from a study involving 35,551 women.[27] The study, designed to prospectively evaluate the relationship between the dietary intake of several carotenoids, vitamin E and vitamin C and the risk of cataract, confirms that women in the highest quintiles of dietary lutein and zeaxanthin (consuming an average of 6.7mg/day) had an 18% lower risk of cataract compared with women in the lowest quintile (consuming an average of 1.2mg/day). As with the relationship between lutein and AMD, the results of the ongoing AREDS2 study may further support the benefits of lutein supplementation in cataracts.

Figure 1: Chemical Structure of Lutein and Lutein Esters (Lutein Dipalmitate is the Example Given)



In lutein esters the hydroxyl group is esterified with two molecules of fatty acid (palmitic acid in this example).

Figure 2: Schematic Diagram of FloraGLO Lutein Production



FloraGLO is a patented and purified free form of lutein that is naturally sourced from the petals of marigold flowers. The marigold extract is subjected to saponification, during which the esters are carefully removed from the lutein. This is followed by purification and crystallisation, which yields purified lutein crystals.

Lutein and Visual Performance in Healthy Subjects

Besides the accumulating evidence on the potentially beneficial role of lutein in risk reduction of degenerative eye diseases such as AMD and cataract, researchers are now focusing their attention and investigations on the possible role of MP in improving visual

performance not only in people with eye diseases but also in young, healthy adults. The scientific rationale for this relationship, originating almost seven decades ago, stems from the blue-light-filtering properties of the MP and the selective accumulation of lutein and zeaxanthin in the region of the retina responsible for central vision. Additionally, it could provide a possible explanation for the specific selection of lutein in the macula to exclusively provide protection from eye diseases that generally manifest after reproductive age.[28]

A recently published cross-sectional study focusing on the relationship between MP, glare disability and photo-stress recovery time has shown that a relationship exists. Lutein and zeaxanthin intake and MPOD values vary considerably across the population. Subjects with higher MPOD were able to tolerate more intense veiling light before losing the capacity to see a target stimulus. Additionally, these subjects were able to recover faster after exposure to a bright light.[28] A subsequent intervention trial has confirmed these initial findings. In young, healthy adults, six months of supplementation with 10mg lutein (FloraGLO Lutein) + 2mg zeaxanthin increased average MPOD value by 39% and improved glare disability as well as photo-stress recovery time. These improvements in visual performance were significantly related to the increase in MPOD.[11]

Final Remarks

The scientific literature shows that the spectral and antioxidant properties of lutein have a beneficial role in eye health. Intervention trials support the use of 10mg lutein for increasing plasma concentrations of lutein, MP accumulation and visual function improvements in healthy individuals as well as in AMD patients. A 10mg daily dose of lutein has been chosen by the investigators of the AREDS2 study to evaluate the efficacy of lutein in AMD, cataract and moderate vision loss. Surveys of ophthalmologists commissioned by Kemin Health Europe and conducted in 2009 and 2010 by Stethos in several European countries[1] suggest that the medical community recognises lutein as an essential ingredient to be recommended in an eye supplement, and more than 96% of the ophthalmologists interviewed have recommended supplements with lutein to their patients. ■

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