WHITE PAPER:

PROTECTIVE ROLE OF LUTEIN AND ZEAXANTHIN ISOMERS AGAINST HIGH-ENERGY BLUE LIGHT EXPOSURE: A NEED ACROSS ALL AGE GROUPS

OmniActive
HEALTH TECHNOLOGIES

PROTECTIVE ROLE OF LUTEIN AND ZEAXANTHIN ISOMERS AGAINST HIGH-ENERGY BLUE LIGHT EXPOSURE: A NEED ACROSS ALL AGE GROUPS

The interest in supplements supporting eye health is increasing and evident in the category's growth: $430 million in 2013 and representing a 53% growth since 2006.[1] Sales among current users of eye health supplements have nearly doubled from 7% in 2011 to 12% currently because of new concerns affecting eye health including exposure to high-energy blue light and sensitivity to glare.[2] While the growth in sales among current eye supplement users is increasing, there is a gap in the broader population that remains untapped, and it is this group that may be most susceptible to issues related to eye health and benefit from long-term supplementation.

A "Digital" Lifestyle Increases High-Energy Blue Light Exposure Risk – A New Concern for All Age Groups

Traditionally, the primary focus within the eye health category has been on an increasingly aging population that is aware of their need for prevention or to address age-related eye conditions.[2] However, the majority of the population, including those who actively take steps to protect their eyes, is unaware of how high-energy blue light affects eye health and to what extent.

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Statistics detailing the magnitude of high-energy blue light exposure demonstrates that all age groups are susceptible to its effects on eye health:

- By 2020, 90% of all indoor light sources are estimated to be LED/CFL[3]
- 88% of American adults have a smart phone, 57% have a laptop, 19% own an e-book reader, and 19% have a tablet computer[4]
- On average, children ages 2 to 5 watch more than 3.5 hours of television in a day[5]
- Children 8 to 10 spend about 5.5 hours each day using media, but they're actually exposed to almost 8 hours of media because they use multiple media simultaneously[5]
- 72% of children age 8 and under have used a mobile device for some type of media activity, up from 38% in 2011[6]
- Time spent online by teens (ages 13 to 17) rose 37%, to just over 4 hours per day, compared to 2012[7]
- Adults spend on average 9.5 hours per day in front of media screens[8]

Developing supplement formulas for this at-risk population translates into new market opportunities across all age groups to include infants, children, adolescents, millennials and healthy adults. Currently, most eye health formulas cater to the approximately 45 million adults with age-related eye conditions. However, the growing category of "digital users" represents a group of 194 million people at risk for developing eye-related issues due to high-energy blue light exposure and a potentially 235% increase in the eye health supplement category.

High-Energy Blue Light & Eye Health: Consequences of Increasing Exposure

The light a human eye responds to is a narrow band of electromagnetic radiation between 390 to 700 nanometers and within this band, high-energy blue light makes up some of the highest energy—between 400 to 500 nanometers. Unlike UV-light exposure, which is almost exclusively from the sun, high-energy blue light is emitted from a multitude of sources including sunlight, digital devices (e.g. computers/laptops, smartphones, television screens, etc.) and artificial indoor lighting, specifically compact fluorescent and LED bulbs. Therefore, compared to UV-light, daily exposure to high-energy blue light from both outdoor and indoor sources is significantly greater.[9]

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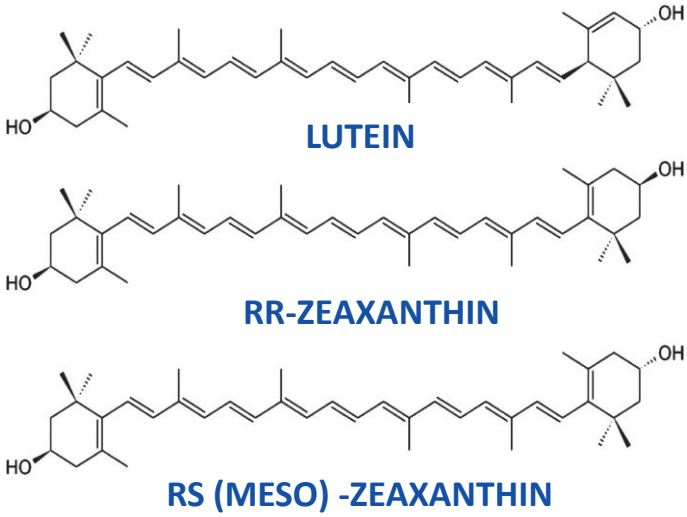
Absorption of almost all ambient UV-light occurs primarily in the cornea and crystalline lens and results of long-term exposure can manifest within the outer layers of the eye as cataracts. High-energy blue light, however, penetrates deeper into the eye and has the potential to damage retinal structures through photochemical and photo-oxidative reactions in the retinal pigment epithelial layer (RPE). Therefore, UV-light from the sun may be less of a causative factor for conditions associated with retinal damage—such as age-related macular degeneration (AMD)—and there are several studies to suggest this.[10,11,12]

Short-term effects of high-energy blue light manifest as "eye fatigue" and are characterized by symptoms including blurry vision, dry eyes and headaches. In a mouse model, it was shown that damage from high-energy blue light can occur within 3 hours of exposure with significant photo-receptor loss after 3 weeks.[13] The mechanisms by which high-energy blue light damages the eye are multifactorial but primarily mediated through photo-oxidative reactions and the generation of reactive oxygen species (ROS).[14] Due to its high metabolic rate and exposure to high-energy blue light, the RPE are a primary target for photo-oxidative damage.

Damage to RPE is a vicious cycle of oxidative stress and inflammation: oxidative stress triggers an inflammatory response and, in turn, inflammation enhances the production of reactive oxygen species (ROS). Without adequate protection, increased oxidative stress inactivates a major proteolytic pathway called the ubiquitin-proteasome pathway (UPP).[14] The UPP functions to degrade unneeded or damaged proteins in all cells and plays a major role in regulatory mechanism central to cellular processing that includes inflammation, immune and stress responses, and antigen processing.[15]

A fully functioning UPP is required for cells to cope with various stress, including oxidation. However, extensive oxidative insults, as seen in RPE exposed to high-energy blue light, can impair UPP, resulting in the accumulation of damaged proteins, dysregulated cell processing and increased inflammation. Since the RPE is a major source of pro-inflammatory

mediators and a primary target of photo-oxidative impairment of UPP, the formation of ROS from high-energy blue light may contribute to inflammation and eye-related issues, like AMD. The damaging effects of high-energy blue light is a cumulative process and often the result of a lack of protection by endogenous mechanisms and antioxidants.[16,17,18] Several nutrients play critical roles in protecting the retina from photo-oxidative damage and perhaps none are more important than the macular carotenoids: lutein and the zeaxanthin isomers.



The Macular Carotenoids: Preferential Protectors Against High-Energy Blue Light

Lutein and the two zeaxanthin isomers, RR-zeaxanthin (3R,3'R-zeaxanthin) and RS (meso)-zeaxanthin (3R,3'S-RS- zeaxanthin), are the only three carotenoids found in the eye, specifically in the macula—the area of the retina responsible for highest visual performance and susceptible to the greatest amount of photo-oxidative damage.[18]

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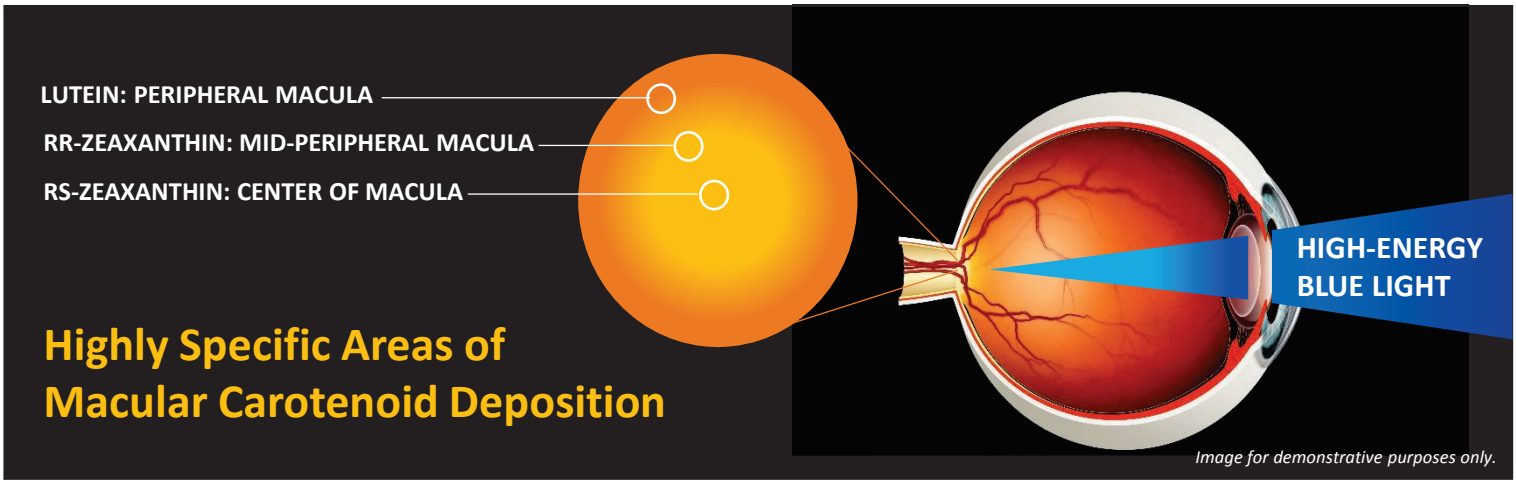
The location of their respective areas of deposition is highly specific: lutein is preferentially deposited in the peripheral macula, RR-zeaxanthin in the mid-peripheral macula and RS-zeaxanthin in the center of the macula.[18] Increased dietary intake of lutein and zeaxanthin is associated with increased macular pigment density (MPOD – the thickness or density of the protective layer of carotenoids in the macula) in healthy adults.[19,20] Epidemiological studies have reported an inverse association between dietary intake of lutein and zeaxanthin and the risk of developing ocular diseases such as AMD and cataracts.[21,22,23]



Each of these carotenoids are important in protecting the retina and enhancing visual performance by acting as high-energy blue light filters, quenching ROS and inhibiting lipid peroxidation of cellular membranes generated from photo-oxidation.[24,25,26] Bian et al., also suggest that aside from its primary role as an antioxidant, lutein and zeaxanthin isomers mitigate the inactivation of UPP and partially reverses photo-oxidation-induced inflammation of RPE.[14]

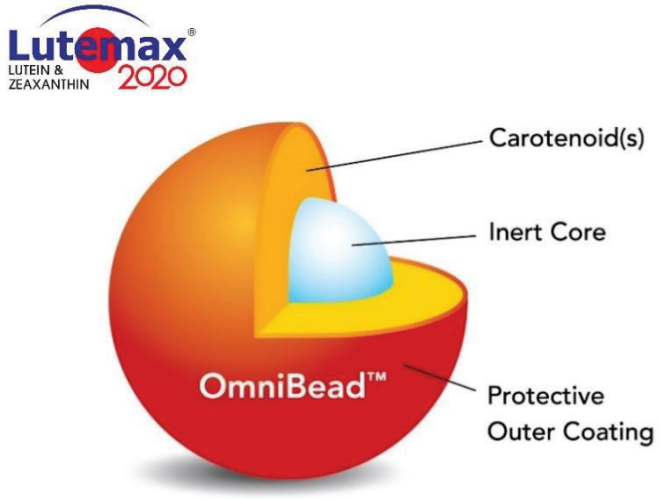
Ensuring optimal levels of all three carotenoids is critical to protecting the eye against high-energy blue light. Lutein and the zeaxanthin isomers absorb different wavelengths of light and together, the three absorb a broader spectrum of high-energy blue light, which offers greater protection of retinal tissue.[27,28,29,30] Supplementation with zeaxanthin resulted in increased levels in the macula and protected against light-induced photoreceptor death.[14] After long-term deficiency, supplementation with lutein or zeaxanthin protected the fovea from high-energy blue light damage.[14] Long-term supplementation with all three carotenoids has demonstrated improvements in eyesight, including visual performance and acuity, reduced glare sensitivity, enhanced contrast sensitivity, improved vision in dim light, and reduced chromatic blur.[31,32,33,34,35,36]

The specialized locations and functions of each macular carotenoid suggests that the best way to support eye health and visual performance is to consume all three macular carotenoids through diet or supplementation. Given that the average US dietary intake of lutein and zeaxanthin is far below levels shown in research to be beneficial (less than 2mg lutein and 0.5mg zeaxanthin), supplementation may be a more viable approach to maintain optimal levels of the macular carotenoids and protect the eyes against high-energy blue light.

Lutemax® 2020–A Balanced Macular Carotenoid Matrix to Protect Against High-Energy Blue Light

While lutein is a potent antioxidant that provides a significant amount of the total carotenoid content of the eye, healthy eyes require more than lutein alone. Lutein and the zeaxanthin isomers absorb different wavelengths of light and together, the three absorb a broader spectrum of high-energy blue light, which offers greater protection of retinal tissue.[27,28,29] Lutemax® 2020 provides lutein and the zeaxanthin isomers—RR- and RS (meso)-zeaxanthin—which are all critical for protecting the macula against high-energy blue light. Lutemax®2020 is a premium lutein with enhanced levels of zeaxanthin isomers in the balanced 5:1 ratio as found in natural dietary sources and contains significantly higher levels of zeaxanthin isomers than other lutein ingredients.[37]

OmniActive provides a wide range of delivery forms of Lutemax® 2020—including powders, beadlets and oil suspensions—for a multitude of application needs. Lutemax® 2020 is produced under a fully vertically integrated supply chain, which means OmniActive controls the entire process from seed development and cultivation of the marigold flowers to finished ingredients and guarantees a consistent and high quality ingredient. Using OmniBead™ technology, OmniActive's Lutemax® 2020 is highly stable and offers formulators a wide range of specifications to cover all product development needs.



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Lutein For Every Age™: Early and consistent lutein intake may help maintain healthy eyes of all ages. Lutein For Every Age™ is an award-winning, educational campaign created by OmniActive Health Technologies to raise awareness of the benefits of early and consistent lutein intake to maintain proper eye, skin, cognitive and general health throughout a lifetime. For more information, visit LuteinForEveryAge.org.

What's You're B.L.U.E.?™: An extension of Lutein For Every Age™, What's Your B.L.U.E.?™ (Blue Light User Exposure) is a exciting new initiative to educate consumers on high-energy blue light, its sources and ways to help protect healthy vision from its effects with the support of the macular carotenoids.

OmniActive Health Technologies: OmniActive Health Technologies offers a range of quality ingredients, which are innovative and scientifically validated for dietary supplementation, nutritional fortification, functional food/beverage, coloring, flavor enhancement and personal care applications. We address complex challenges for customers in the dietary supplement, food and beverage space using technology-driven, sustainable solution with application support within a global regulatory framework. Whether you're looking for a new ingredient to add to a finished product, or technology to enhance an existing ingredient, you'll find unmatched innovation at OmniActive.

Our core products are carotenoids, spice, plant extracts and specialty functional ingredients. We leverage our international R&D strengths to deploy an array of state of the art manufacturing technologies in extraction, purification, isolation and delivery of nutritional actives. Our manufacturing operations are located at multiple sites in India and are cGMP and HACCP system compliant. For more information on OmniActive or our award-winning ingredients, technologies, education initiatives, marketing campaigns or research, visit omniactives.com.

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These statements have bot been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure, or prevent and disease.

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