Website : www.asthafoundation.in
Frontiers in Crop Improvement
Vol 10 : 2930-2934 (Special Issue-VI) December 2022, Print ISSN : 2393-8234 Online ISSN : 2454-6011
Astha Foundation, Meerut (U.P.) India

Health Benefits of Lutein

S. Shil[1]*, Pabitra Adhikary[2] and Joydip Mandal[3]
[1]*Krishi Vigyan Kendra, Khowai Tripura*
[2]*Krishi Vigyan Kendra, North 24 Parganas*
[3]*Department of Horticulture & Post Harvest Technology, Viswa Bharati, Sriniketan*
**Email: subhrasmily@gmail.com*

Abstract

Luteinis a yellow pigment of carotenoid family. Lutein is synthesized only by plants and is found in high quantities in green leafy vegetables such as spinach, kale and yellow carrots. In green plants, xanthophylls act to modulate light energy and serve as non-photochemical quenching agents to deal with triplet chlorophyll. The human body cannot synthesize lutein or another vision boosting antioxidant, zeaxanthin, on its own, so these nutrients must be obtained through diet. Of the 600 carotenoids found in nature, lutein and zeaxanthin are the only two that the body sends to the macular portion of the eyes, where they fight free radical damage that can lead to macular degeneration and cataracts.

Key words : *Lutein, health, benefits.*

Introduction

The word Lutein derived from Latin word *luteus* meaning "yellow". Lutein is a yellow pigment of carotenoid family. Lutein is synthesized only by plants and is found in high quantities in green leafy vegetables such as spinach, kale and yellow carrots. In green plants, xanthophylls act to modulate light energy and serve as non-photochemical quenching agents to deal with triplet chlorophyll (an excited form of chlorophyll), which is overproduced at very high light levels, during photosynthesis. Egg yolk and maize (corn) contained the highest mole percentage (% of total) of lutein and zeaxanthin (more than 85% of the total carotenoids). Maize was the vegetable with the highest quantity of lutein (60% of total) and orange pepper was the vegetable with the highest amount of zeaxanthin (37% of total). Substantial amounts of lutein and zeaxanthin (30-50%) were also present in kiwi fruit, grapes, spinach, orange juice, zucchini (or vegetable marrow), and different kinds of squash (Sommerburg *et al,* 1998). The flower Marigold (*Tagetes Erecta* L.) also represents a rich source of lutein. Dried Marigold flowers contain 0.1 -0.2 % dry matter (DM) of carotenoids, out of which 80% are lutein diesters (Miroslav *et al*. 2014). The human body cannot synthesize lutein or zeaxanthin on its own, which means we must obtain these important nutrients from our diet (or in some cases, supplements). In plants, Lutein is present either in the form of free lutein or in the form of esters with fatty acids (Khachik *et al*. 1986: Breithaupt & Bamedi 2001 and Calvo 2005). Where lutein is present in plants as fatty-acid esters, with one or two fatty acids bound to the two hydroxyl-groups, saponification (de-esterfication) of lutein esters to yield free lutein may yield lutein in any ratio from 1:1 to 1:2 molar ratio with the saponifying fatty acid.

Absorption and Metabolism : Mammalians are not able to synthesize carotenoids which therefore need to be introduced with food (Eroglu *et al*., 2013). Once consume, lutein is absorbed by the mucosa of the small bowel and bound to chylomicrons, then, it is secreted into lymph and reaches the liver (Parker 1996). In hepatocytes, lutein is incorporated into lipoproteins that are distributed to peripheral tissues (Clevidence 1993), particularly the retina, where the highest concentrations have been demonstrated. Lutein being fat soluble the dietary content of lipids mediates lutein absorption through its incorporation into micelles (Unlu *et al.* 2005), and several dietary factors may compete.

Dietary fat is important for the absorption of xanthophyll carotenoids like lutein and zeaxanthin. Fat stimulates bile flow from the gall bladder to emulsify fat-soluble vitamins into lipid micelles – microscopic fat droplets – so they can be absorbed in the small intestine. Inadequate fat intake can result in reduced absorption of carotenoids, even if the diet is carotenoid rich. On the other hand, some competition for absorption is observed when similar structured carotenoids like beta-carotene and lutein are consumed together. (Loane E, *et al*. 2008). A diet rich in fiber has been reported to reduce carotenoid serum levels (Rock and Swendseid 1992, Riedl *et al*.1999), also affecting lutein absorption. The content of iron and zinc as well as protein deficiency may affect lutein absorption (Williams *et al*. 1998).

Mechanisms of Action : The macular region of the primate retina is yellow in color due to the presence of the macular pigment, composed of two dietary xanthophylls,

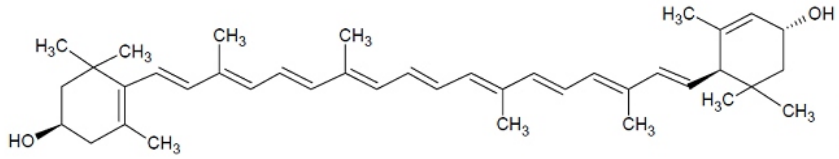

Figure 1. Structural formula of lutein

Some foods are considered good sources of the nutrients: (SanGiovanni et al., Niizu et al., USDA Database)

Product	Lutein/zeaxanthin (mg/100g)
Nasturtium (Yellow flowers, Lutein levels only)	45,000 [28]
Kale (Raw)	39,550
Kale (Cooked)	18,246
Dandelion Leaves (Raw)	13,610
Nasturtium (Leaves, Lutein Levels Only)	13,600 [28]
Turnip Greens (Raw)	12,825
Spinach (Raw)	12,198
Spinach (Cooked)	11,308
Swiss Chard (Raw Or Cooked)	11,000
pararsid11038589 Turnip Greens (Cooked)	8440
Collard Greens (Cooked)	7694
Watercress (Raw)	5767
Garden Peas (Raw)	2593
Romaine Lettuce	2312
Zucchini	2125
Brussels Sprouts	1590
Pistachio Nuts	1205
Broccoli	1121
Carrot (Cooked)	687
Maize/Corn	642
Egg (Hard Boiled)	353
Avocado (Raw)	271
Carrot (Raw)	256
Kiwifruit	122

lutein and zeaxanthin, and another xanthophyll, meso-zeaxanthin. The latter is presumably formed from either lutein or zeaxanthin in the retina. By absorbing blue-light, the macular pigment protects the underlying photoreceptor cell layer from light damage, possibly initiated by the formation of reactive oxygen species during a photosensitized reaction. There is ample epidemiological evidence that the amount of macular pigment is inversely associated with the incidence of age-related macular degeneration, an irreversible process that is the major cause of blindness in the elderly. The macular pigment can be increased in primates by either increasing the intake of foods that are rich in lutein and zeaxanthin, such as dark-green leafy vegetables, or by supplementation with lutein or zeaxanthin. Although increasing the intake of lutein or zeaxanthin might prove to be protective against the development of age-related macular degeneration, a causative relationship has yet to be experimentally demonstrated. (Norman 2003)

Both animal and in vitro studies demonstrated that some carotenoids are compounds with antioxidant activity (Fiedor and Burda 2014, Young and Lowe 2001). Lutein has been demonstrated to exert an extremely potent antioxidant action by quenching singlet oxygen and scavenging free radicals (Kim *et al*, 2006). Another protective effect of lutein consists in the ability of filtering blue light, thus reducing phototoxic damage to photoreceptor cells (Junghans *et al*. 2001). Notably, several studies have observed that lutein inhibits both the pro-inflammatory cytokine cascade (Chung *et al.* 2017). Through all these mechanism(s), it is quite conceivable that lutein may exert a key role in regulating immune pathways, modulating inflammatory responses, and reducing oxidative damage.

Lutein Intake : Lutein is naturally abundant and available in fruit, cereals, and vegetables, and it is also present in egg yolk (Perry *et al*., 2009), where its bioavailability is higher than in any other food (Chung *et al*., 2004). Interestingly, the highest lutein intake was reported in Pacific countries, where individuals consume a diet extremely rich in fruit and vegetables, reaching the peak of about 25 mg/d in the Fiji Islands (Augood *et al*., 2006). Currently, there are no established upper limits for lutein and zeaxanthin intake neither for adults nor for pregnant

women. A systematic risk assessment of lutein supplements in placebo-controlled intervention trials indicate that lutein is safe up to 20 mg/day; however these levels are not sufficient to draw confident conclusions on long-term safety (Omenn *et al*., 1996). Some positive health effects have been seen at dietary intake levels of 6–10 mg/day (Moukarzel *et al*., 2009) The only definitive side effect of excess lutein consumption is bronzing of the skin (carotenodermia).

Benefits of Lutein

Protects Against Eye Disorders Like Macular Degeneration : Lutein is considered a natural treatment for mascular degeneration (AMD), which is considered the most common cause of blindness among older adults. Estimates show that more than 25 million people worldwide are affected by age-related macular degeneration or cataracts, especially people aged 55 and older living in industrialized Western nations. Several studies show that an increase in macula pigmentation decreases the risk for eye diseases such as age-related maculaar degeneration (AMD). (Richer, 1999., Richer et al, 2004., Age-Related Eye Disease Study Research Group (2001).

Lutein protects the eyes by filtering out a percentage of damaging short-wavelength UV light that negatively affects delicate parts of the eyes such as the retina (the macula). Researchers at Harvard University have found that supplementing with 6 milligrams daily of lutein can lower the risk for mascular degeneration by an average of 43 percent.

Lowers the risk of cataract development : There is also epidemiological evidence that increasing lutein and zeaxanthin intake lowers the risk of cataract development (San Giovanni et al. 2007.,). Consumption of more than 2.4 mg of lutein/zeaxanthin daily from foods and supplements was significantly correlated with reduced incidence of nuclear lens opacities, as revealed from data collected during a 13- to 15-year period in the Nutrition and Vision Project (NVP) (Barke, 2010)

Two meta-analyses confirm a correlation between high diet content or high serum concentrations of lutein and zeaxanthin and a decrease in the risk of nuclear cataract, but not cortical or subcapsular cataract (Liu *et al.* 2014., Ma *et al.* 2014). While the research is still in its early stages, taking lutein three times weekly for up to two years has been shown to improve vision in older people who already have cataracts.

Helps Protect Skin Health : In addition to being found within the pigments of our eyes, carotenoids including lutein and zeaxanthin are also present within the skin. To preserve skin health and fight skin cancer, lutein helps filter high-energy wavelengths of visible light, which slows down the rate of oxidative stress. Some animal studies show evidence that lutein offers significant protection against light-induced skin damage, such as signs of aging and potentially skin cancer.

Can Help Lower Diabetes Risk : According to some animal studies, higher levels of lutein and other carotenoids within the blood are linked with fewer problems controlling blood sugar and a lower risk for diabetes or related complications. A 2000 study conducted on diabetic rats found that supplementing with lutein and DHA (a crucial type of omega-3 fatty acid) helped normalize all diabetes-induced biochemical modifications.

Might Help Lower Risk of Cancer : Some evidence shows that people who obtain more lutein from their diet experience lower rates of breast, colon, cervical and lung cancers. While we don't know exactly how lutein and cancer formation is tied just yet, correlational studies have shown that adults with higher levels of lutein in the blood experience a reduced risk of developing several forms of common cancers.

Lutein may act as a natural cancer treatment because of the fact that foods rich in lutein (like leafy greens and citrus fruits) also provide other beneficial antioxidants and nutrients that lower disease-causing inflammation and oxidative stress. However, at this time, more research is still needed to help us fully understand the effects of lutein and other carotenoids on cancer, immune, hormonal and cardiovascular health, independent of other nutrients that are found in fruits and vegetables.

Can Help Maintain Heart Health : Some observational studies show that xanthophyll carotenoids including lutein can help reduce the risk of developing heart disease and stroke. Just like with the previously mentioned studies that show potential cancer-protective effects of lutein, we aren't exactly sure yet how lutein improves heart health. Because lutein has anti-inflammatory and antioxidant properties, it seems that it would benefit heart health by lowering inflammation, which is an underlying cause of coronary heart disease.

Mammalian development : Evidence has recently supported the role of lutein and zeaxanthin also in mammalian development, specifically in relationship to their potential protective activity on infant retinal and brain development and functions. It remains to be established whether or not these are the only body sites where accumulation of xanthophylls may be beneficial to the developing fetus and rapidly growing infant. Most of the human data derive from observational studies that are generally complicated by a number of variables, which

have an impact on carotenoid and metabolites in serum and tissues (Elena and Loredana, 2018). Higher maternal lutein and zeaxanthin intake during pregnancy was associated with better offspring verbal intelligence and behavior regulation ability in mid-childhood, suggesting a potential benefit during prenatal development. (Hiya , 2021)

Industrial uses of lutein

Food, beverage and Pharmaceuticals : The natural pigment is widely used in food as feed additives, cosmetic and pharmaceutical industry.

Cosmetics : The oil may be added to perfumes to infuse an apple scent into them. It is also used in washing the skin.

Coloring agent : It is used as a yellow dying agent.

Culinary : In salads and other foods to add colour and flavour in them.

Animal Feed : Finds application as poultry feed to ensure a good colouration of egg yolks and broiler skin.

Conclusions

The most recent data available from the WHO estimate that 285 million people in the world are visually-impaired while 39 million are legally blind (Pascolini and Mariotti, 2012). Several studies have suggested that lutein and zeaxanthin play critical roles in delaying the onset and reducing the risk of cataract and age-related macular degeneration (AMD), both of which are responsible for 56% of all cases of blindness globally (Bone *et al.,* 2007, Bone and Landrum, 2010, Ma *et al.,* 2012b, Murray *et al.,* 2013, Pascolini and Mariotti, 2012).

Since 80% of all visual impairments are avoidable or curable, it has become pertinent to undertake a comprehensive review of the contributions of dietary lutein and zeaxanthin to visual health with a view to highlighting the position of these xanthophylls as critical players in reducing the incidence of ocular abnormalities. It is found in brightly colored foods like fruits and vegetables. The human body cannot synthesize lutein or another vision boosting antioxidant, zeaxanthin, on its own, so these nutrients must be obtained through diet. Of the 600 carotenoids found in nature, lutein and zeaxanthin are the only two that the body sends to the macular portion of the eyes, where they fight free radical damage that can lead to macular degeneration and cataracts.

References

1. Age-Related Eye Disease Study Research Group (October 2001). "A randomized, placebo-controlled, clinical trial of high-dose supplementation with vitamins C and E, beta carotene, and zinc for age-related macular degeneration and vision loss: AREDS report no. 8". *Arch. Ophthalmol.* 119 (10): 1417–36.
2. Augood C.A., Vingerling J.R., de Jong P.T., Chakravarthy U., Seland J., Soubrane G., Tomazzolis L., Topouzis F., Bentham G., Rahu M., 2006. Prevalence of age-related maculopathy in older Europeans: The European Eye Study (EUREYE) Arch. *Ophthalmol.* 124: 529–535.
3. Barker Fm, 2nd (2010). Dietary supplementation: effects on visual performance and occurrence of AMD and cataracts. *Current medical research and opinion*. 26 (8): 2011–23.
4. Bone R, Landrum J.T, Yisi Cao, 2 Howard A. N,3 and Francesca A.C. (2007). Macular pigment response to a supplement containing meso-zeaxanthin, lutein and zeaxanthin. Nutrition & Metabolism. 4: 12
5. Breithaput D. E., Bamedi A. (2001). Carotenoids esters in vegetables and fruits: a screening with emphasis on Beta cryptoxanthin esters. *Journal of Agricultural and Food Chemistry.* 49: 2064-2070.
6. Chung H.Y., Rasmussen H.M., Johnson E.J. 2004. Lutein bioavailability is higher from lutein-enriched eggs than from supplements and spinach in men. *J. Nutr.* 134: 1887–1893.
7. Chung R.W.S., Leanderson P., Lundberg A.K., Jonasson L. 2017. Lutein exerts anti-inflammatory effects in patients with coronary artery disease. *Atherosclerosis*. 262: 87–93.
8. Clavo M.M. (2005). Lutein: a valuable ingredients of fruits and vegetables. *Critical Review in Food Science and Nutition.* 45: 671-696.
9. Clevidence B.A., Bieri J.G. Association of carotenoids with human plasma lipoproteins. Methods Enzymol. 1993;214:33–46. doi: 10.1016/0076-6879(93)14051-J
10. Elena Giordano and Loredana Quadro 2018. Lutein, zeaxanthin and mammalian development: metabolism, functions and implications for health. *Arch Biochem Biophys.* 647: 33–40.
11. Eroglu A., Harrison E.H. Carotenoid metabolism in mammals, including man: Formation, occurrence, and function of apocarotenoids. *J. Lipid Res.* 2013; 54: 1719–1730.
12. Fiedor J., Burda K. 2014. Potential role of carotenoids as antioxidants in human health and disease. Nutrients. 6: 466–488.
13. 0;Hiya A Mahmassani, 0;Karen M Switkowski, 0;Tammy M Scott, 0;Elizabeth J Johnson, 0;Sheryl L Rifas-Shiman, 0;Emily Oken, 0;Paul F Jacques. 2021. Maternal Intake of Lutein and Zeaxanthin during Pregnancy Is Positively Associated with Offspring Verbal Intelligence and Behavior Regulation in Mid-Childhood in the Project Viva Cohort. *The Journal of Nutrition.* 151(3) : 615–627.
14. Junghans A., Sies H., Stahl W. 2001. Macular pigments lutein and zeaxanthin as blue light filters studied in liposomes. *Arch. Biochem. Biophys.* 391: 160–164.
15. Khachik F., Beecher G.R., Whittaker N.F. (1986). Separation, identification and quantification of the major carotenoids and chlorophyll constituents in concentrates of several green vegetables by liquid chromatography. *Journal of Agricultural and Food Chemistry*, 34: 603:616.

16. Kim S.R., Nakanishi K., Itagaki Y., Sparrow J.R. 2006. Photooxidation of A2-PE, a photoreceptor outer segment fluorophore, and protection by lutein and zeaxanthin. *Exp. Eye Res.* 82: 828–839.
17. Landrum J, Bone R, Mendez1 V, Valenciaga A and Babino D. 2012. Comparison of dietary supplementation with lutein diacetateand lutein: a pilot study of the effects on serum and macular pigment. *Acta Biochimica Polonica* 59(1): 167–169.
18. Liu XH, Yu RB, Liu R, Hao ZX, Han CC, Zhu ZH, Ma L (2014). Association between lutein and zeaxanthin status and the risk of cataract: a meta-analysis. *Nutrients.* 6(1): 452–65.
19. Loane E, 2008. Transport and retinal capture of lutein and zeaxanthin with reference to age-related macular Degeneration. *Surv Ophthalmol* 53: 68-81.
20. Ma L, Hao ZX, Liu RR, Yu RB, Shi Q, Pan JP (2014). "A dose-response meta-analysis of dietary lutein and zeaxanthin intake in relation to risk of age-related cataract". *Graefes Arch. Clin. Exp. Ophthalmol.* 252 (1): 63–70.
21. Miroslav Sivel, Stanislav Kracmar, Miroslav Fisera,Borivoj Klejdua and Vlastimil Kuban. (2014). Lutein Content in Marigold Flower (*Tagetes erecta* L.) Concentrates used for Production of Food Supplements. *Czech J. Food Sci.* 32(6): 521-525.
22. Moukarzel A.A., Bejjani R.A., Fares F.N. 2009. Xanthophylls and eye health in infants and adults. *J. Med. Liban.* 57: 261–267.
23. Niizu, P.Y.; Delia B. Rodriguez-Amaya (2005). Flowers and Leaves of Tropaeolum majus L. as Rich Sources of Lutein. *Journal of Food Science.* 70 (9): S605–S609.
24. Omenn G.S., Goodman G.E., Thornquist M.D., Balmes J., Cullen M.R., Glass A., Keogh J.P., Meyskens F.L., Jr., Valanis B., Williams J.H., Jr., 1996. Risk factors for lung cancer and for intervention effects in CARET, the Beta-Carotene and Retinol Efficacy Trial. *J. Natl. Cancer Inst.* 88: 1550–1559.
25. Parker R.S. 1996. Absorption, metabolism, and transport of carotenoids. FASEB J. 10: 542–551. doi: 10.1096/fasebj.10.5.8621054
26. Pascolini, D. and Mariotti, S.P. (2012) Global Estimates of Visual Impairment: 2010. *British Journal of Ophthalmology*, 96, 641-648.
27. Perry A., Rasmussen H., Johnson E.J. 2009. Xanthophyll [lutein, zeaxanthin] content in fruits, vegetables and corn and egg products. *J. Food Compos. Anal.* 22: 9–15.
28. Richer S (January 1999). ARMD—pilot (case series) environmental intervention data. J Am Optom Assoc. 70 (1): 24–36.
29. Richer S, Stiles W, Statkute L (April 2004). Double-masked, placebo-controlled, randomized trial of lutein and antioxidant supplementation in the intervention of atrophic age-related macular degeneration: the Veterans LAST study (Lutein Antioxidant Supplementation Trial). Optometry. 75 (4): 216–30.
30. Riedl J., Linseisen J., Hoffmann J., Wolfram G. 1999. Some dietary fibers reduce the absorption of carotenoids in women. *J. Nutr.* 129: 2170–2176.
31. Rock C.L., Swendseid M.E. 1992. Plasma beta-carotene response in humans after meals supplemented with dietary pectin. *Am. J. Clin. Nutr.* 55: 96–99.
32. SanGiovanni JP, Chew EY, Clemons TE (2007). The relationship of dietary carotenoid and vitamin A, E, and C intake with age-related macular degeneration in a case-control study: AREDS Report No. 22". *Arch. Ophthalmol.* 125 (9): 1225–32.
33. Sommerburg O, Keunen JE, Bird AC and van Kuijk FJ. (1998). Fruits and vegetables that are sources for lutein and zeaxanthin: the macular pigment in human eyes. *Br J. Ophthalmol.* 82(8): 907-10.
34. Unlu N.Z., Bohn T., Clinton S.K., Schwartz S.J. 2005. Carotenoid absorption from salad and salsa by humans is enhanced by the addition of avocado or avocado oil. J. Nutr. 135: 431–436.
35. USDA National Nutrient Database for Standard Reference, Release 23 (2010)
36. Williams A.W., Boileau T.W., Erdman J.W., Jr. 1998. Factors influencing the uptake and absorption of carotenoids. Proc. Soc. Exp. Biol. Med. 218: 106–108.