



Position Statement for Healthcare Professionals

Eggs and Eye Health

Updated June 2012

Age-related eye disorders are the leading causes of vision impairment and blindness in Australia [1]. These disorders include cataracts, age-related macular degeneration (AMD), diabetic retinopathy and glaucoma [1]. The major risk factors for age-related eye disorders include smoking, family history and increasing age [2, 3]. Evidence indicates that several dietary factors such as antioxidant intake [4], fat types [5], omega-3 intake [6], glycemic index [7] and adequate intake of key vitamins and minerals play an important role in the development and progression of some of these disorders including AMD and cataracts. Improved diabetes control, which ideally involves dietary modification, also reduces the risk of developing, and the progression of, diabetic retinopathy [8].

Antioxidants and Eye Disease

Lutein and zeaxanthin are the two primary carotenoids found in the macular region of the retina [9]. As the retina suffers progressive oxidative damage with age, it is thought that lutein and zeaxanthin may play a protective role in the prevention of eye disease. Lutein accumulates in the front of the macula and macular pigment density is inversely associated with AMD [3]. In reviews of human studies, evidence suggests dietary intake of lutein and zeaxanthin can lead to their accumulation in the retina, and as a result may provide protection against retinal degeneration [10-12]. Furthermore, a review of population studies has shown that lutein and zeaxanthin (from plant sources) may also provide protection against age-related cataracts and AMD [10]. The Blue Mountains Eye Study (BMES) showed that for dietary lutein and zeaxanthin, elderly participants in the top tertile of intake had a reduced risk of developing late AMD (RR 0.35) [4]. This finding is backed up by a recent systematic review which suggests that dietary lutein and zeaxanthin is not significantly associated with a reduced risk of early AMD, but may be protective against late AMD [13]. A 2010 scientific review article [14] has confirmed that an optimal supply of lutein and zeaxanthin, as well as the omega-3 fatty acids DHA and EPA, are essential for eye health as they have the potential to protect the eye and may also help in the prevention and/or treatment of age-related eye diseases, such as AMD in the elderly.

Several mechanisms have been proposed as to how lutein and zeaxanthin may protect the eye including through the absorption of damaging blue light and via the antioxidant properties of these compounds which protect the retina and photoreceptors in the eye against free radical damage [11]. One study [15] showed that retinal lutein and zeaxanthin reduce glare disability and discomfort, reduce photostress recovery times, and enhance contrast. More recent evidence also suggests that lutein plays a systemic anti-inflammatory role which may help protect against AMD [16]. Although it is unclear why some people develop AMD it has been suggested there may be a problem with the uptake of lutein and zeaxanthin by the eye [17].

Eggs contain both of the antioxidants lutein and zeaxanthin, with one serve* of eggs containing around 530ug. While this is lower than some plant sources, it has been shown that the bioavailability of carotenoids is determined by the characteristics of the food in which they are contained and with the interactions they have with other dietary constituents. For example, the localisation of carotenoids within the chloroplasts and chromoplasts of plants may decrease bioavailability [18] and the dietary fibre from plant sources, such as pectin and guar gum, has also been shown to reduce carotenoid absorption [19].



On the other hand, fat may increase the bioavailability of carotenoids. Egg yolks are a matrix of digestible lipids, with lutein and zeaxanthin dispersed within it, along with other fat-soluble micronutrients. Lutein and zeaxanthin in egg yolk may therefore be highly bioavailable due to their association with this lipid matrix [20, 21]. One study has shown that consuming 1.3 egg yolks per day for 4.5 weeks can increase plasma zeaxanthin concentrations by more than 100%, and plasma lutein concentrations by 28-50% [20]. In contrast, spinach and corn, although having a high content of zeaxanthin, do not raise plasma zeaxanthin concentrations [22].

Currently there is insufficient research to indicate an exact optimal level of intake of lutein and zeaxanthin for protecting against eye disease. However data from the BMES indicates that in older Australians, those with a dietary lutein and zeaxanthin intake of more than 942mcg/day, along with the highest intake of vegetables, were less likely to develop AMD [4].

Earlier reports from the BMES showed that women had slightly higher intakes than men [23]. The main contributors to lutein and zeaxanthin intakes were broccoli, green beans and oranges. No other Australian studies have assessed the intake of these antioxidants in other population sub-groups however current intakes in elderly people are lower than ideal.

Due to both their high bioavailability and not being subject to seasonal variation, the consumption of eggs is a favourable source of lutein and zeaxanthin in the diet.

Antioxidants and Eggs

No studies have specifically investigated associations of antioxidants from egg consumption with eye disease risk. However, in the Beaver Dam Eye Study, egg consumption was inversely associated with nuclear cataract risk among members of the cohort who were less than 65 years of age at baseline [24]. Persons in the highest quintile of egg consumption had a 60% lower risk of developing cataract compared to those in the lowest quintile of intake. The logistic regression statistical analysis made adjustments for age and energy intake.

A number of studies have assessed egg consumption as a vehicle for increased uptake of the antioxidants lutein and zeaxanthin, with results supporting previous findings in this area [25]. For example, a study among 33 men and women aged 60 years and over found that eating one egg a day for five weeks significantly increased the levels of serum lutein and zeaxanthin without increasing blood cholesterol levels [26]. Serum lutein concentration increased by 26% from baseline while zeaxanthin increased by 38% ($P < 0.05$). Similarly another study showed that eating six eggs a week for 12 weeks increased macular pigment optical density (MPOD) without increasing blood cholesterol levels in 24 females aged 24-59 years [27]. Serum zeaxanthin also increased in the egg treatment groups. Because greater macular pigment density means better protection of the eyes, the researchers suggested a potential role in reducing the risk of AMD.



Another study tested the effect of eating 2 and 4 egg yolks per day on blood levels of lutein and zeaxanthin and macular pigment optical density (MPOD) in adults taking cholesterol lowering medications. Subjects consumed foods containing 2 followed by 4 egg yolks/day for 5 weeks each with a 4-wk egg-free period at baseline and between the 2 interventions. Results showed that consumption of 2 and 4 egg yolks per day for 5 weeks increased MPOD and benefited macular health in older adults with low MPOD. Blood levels of lutein and zeaxanthin were raised with increasing intakes of egg, as was "good" HDL cholesterol. On the contrary, "bad" LDL cholesterol did not change.[28]

The effects of feeding omega-3 enriched eggs and organic eggs on blood levels of lutein, zeaxanthin and beta-carotene were studied in 20 healthy lacto-ovo-vegetarian adults [29]. Subjects were classed into three groups 1) six organic eggs per week 2) six omega-3 enriched eggs per week 3) no eggs, for eight weeks. Results found blood levels of lutein were significantly higher in both egg groups compared with no eggs. There was no difference between the two types of eggs. No significant differences were seen for beta-carotene and zeaxanthin. In this study omega-3 enriched eggs and organic eggs were shown to significantly increase serum lutein levels in lacto-ovo-vegetarians, however regular eggs were not tested.

The conclusion that can be drawn from the research to date is that eggs are a highly bioavailable source of dietary carotenoids and that they are an effective vehicle for increased and site-specific antioxidant uptake. This in turn may have benefits for long term eye health.

Antioxidant Supplement Studies

Studies have been conducted using dietary supplements of lutein and zeaxanthin [30-32], with results showing that supplementing lutein and zeaxanthin at 2.4-30mg/d, and 30mg/day respectively increases serum concentrations of these carotenoids. In one study of older male patients with AMD they were supplemented with 8mg zeaxanthin (Zx); 8mg Zx + 9mg Lutein or 9mg Lutein. Each supplement group improved symptoms of AMD[31]. Lutein supplementation of 20mg for 3 months plus 10mg for 3 months also improved macular pigment optical density (MPOD) in 126 patients with AMD[32].

Omega-3, Fats and Eye Health

The essential long chain omega-3 fatty acid docosahexaenoic acid (DHA) is a major structural lipid found in the photoreceptors of the retina, affecting the permeability, fluidity and thickness functions of the photoreceptor membranes. Deficiency of DHA is associated with alterations in the functioning of the retina and visual processing. Adequate intake of long-chain omega-3 can protect the eye from retinal damage caused by ischemia, oxidation, light, inflammation and age-associated diseases [33]. Some research has shown that lower intakes of saturated fat and higher intakes of omega-3 fatty acids are protective against the development of certain eye diseases [6, 34, 35], while vegetable fats and monounsaturated fats are associated with a greater risk of developing advanced AMD [34, 36]. However, Australian research does not support this. In the Blue Mountains Eye Study of 3654 persons aged 49 years and over, there was no association between incident AMD and butter, margarine, or nut consumption [37]. Overall, research in the area of fats and eye disease is limited and the results highly variable, however there is some consistency in the finding that higher intakes of fish and/or omega-3 fats may be protective. Of note, a 2011 study has found regular consumption of omega-3 is associated with a reduced risk of age-related macular degeneration in women [38]. Omega 3 intake may also slow the decline of visual acuity in the eye condition, retinitis pigmentosa [39].



In addition to fish, other sources of omega-3 fats include walnuts, canola oil, linseeds and eggs. A serve of eggs provides 12-20% AI of omega-3s and 71-127% AI of the long chain omega-3s for adults. A low saturated fat diet is also recommended for all people for optimal health. Recently the European Food Safety Authority (EFSA) asserted that taking a dose of 250 milligrams of the omega-3 fatty acid DHA each day, can make an important contribution towards maintaining vision [40].

Other Nutrients in Eggs

In addition to lutein and zeaxanthin, adequate intakes of vitamin A, other antioxidants and zinc are thought to reduce the amount of visual degeneration in the elderly [41]. For instance, results from the BMES showed that those consuming the highest amount of zinc per day (≥ 15.8 mg/day) were significantly less likely to develop AMD than the remaining population [4]. For people aged 51 years and over, one serve of eggs* provides bioavailable vitamin A (34% RDI for women, 27% RDI for men), vitamin E (34% AI for women, 24% AI for men), selenium (68% RDI for women, 59% RDI for men), and zinc (6% RDI for women, 4% RDI for men).

Dietary and lifestyle effects on eye health

Studies have linked glycemic index (GI) and body mass index (BMI) with eye disease. Despite previous research showing no evidence of a high glycemic index diet increasing the risk of cataracts [42], a recent study has indicated that people with the highest GI diets were 1.29 times more likely to have nuclear opacities (cataracts) than those with lower GI diets [43]. Results from a 2007 study also found that those consuming a diet with a high GI (>77.9 for women and 79.3 for men) had a 49% increase in the risk of AMD, and that 20% of prevalent cases of AMD would have been eliminated if participants had a dietary GI below these values [7]. The Nurse's Health Study also showed that consuming a high GI diet almost tripled the development of AMD (odds ratio = 2.7) compared to lower GI diets [44]. BMI is another modifiable lifestyle factor associated with AMD. The Age-Related Eye Disease Study (AREDS) showed obese people with early or intermediate AMD were almost twice as likely to develop central geographic atrophy (lesions associated with dry AMD), and thus progress to advanced AMD, when compared to non-obese people [45]. In addition, the impact of egg consumption on plasma lutein levels appears to be influenced by body mass index and waist circumference. A cross-over study in 22 postmenopausal women showed that improvements in plasma lutein after egg consumption were less likely in those with a body mass index above 29 [46].

Conclusion

Eggs contain a range of nutrients and antioxidants that have been shown to contribute to long-term eye health. Eggs can therefore be enjoyed regularly as part of a healthy lifestyle that also includes the following:

- Smoking avoidance
- Enjoying 1-2 fish meals per week
- Eating other foods rich in carotenoids such as dark green and orange/yellow fruit and vegetables daily
- Reducing dietary sources of saturated fat
- Exercising regularly to control body weight and blood pressure
- Reducing the glycaemic index of the diet
- If overweight, aiming for weight loss to assist with controlling blood glucose levels
- For people with type 2 diabetes, achieving and maintaining optimal blood glucose and plasma lipid levels.



This statement is for healthcare professionals only.

**One serve = 2x60g eggs (104g edible portion)*

RDI: Recommended Dietary Intake

AI: Adequate Intake

Useful links:

<http://www.mdfoundation.com.au/>

<http://cera.unimelb.edu.au/>



References:

1. AIHW, Australia's Health 2006: the tenth biennial health report. 2006, Australian Institute of Health and Welfare: Canberra.
2. Cho, E., et al., Prospective study of intake of fruits, vegetables, vitamins, and carotenoids and risk of age-related maculopathy. *Arch Ophthalmol*, 2004. **122**(6): p. 883-92.
3. Ribaya-Mercado, J.D. and J.B. Blumberg, Lutein and zeaxanthin and their potential roles in disease prevention. *J Am Coll Nutr*, 2004. **23**(6 Suppl): p. 567S-587S.
4. Tan, J.S., et al., Dietary Antioxidants and the Long-term Incidence of Age-Related Macular Degeneration The Blue Mountains Eye Study. *Ophthalmology*, 2007.
5. Robman, L., et al., Dietary lutein, zeaxanthin, and fats and the progression of age-related macular degeneration. *Can J Ophthalmol*, 2007. **42**(5): p. 720-6.
6. Hodge, W.G., et al., The evidence for efficacy of omega-3 fatty acids in preventing or slowing the progression of retinitis pigmentosa: a systematic review. *Can J Ophthalmol*, 2006. **41**(4): p. 481-90.
7. Chiu, C.J., et al., Association between dietary glycemic index and age-related macular degeneration in nondiabetic participants in the Age-Related Eye Disease Study. *American Journal of Clinical Nutrition*, 2007. **86**(1): p. 180-8.
8. Taylor, H.R., Diabetic retinopathy. *Clin Experiment Ophthalmol*, 2005. **33**(1): p. 3-4.
9. Pratt, S., Dietary prevention of age-related macular degeneration. *J Am Optom Assoc*, 1999. **70**(1): p. 39-47.
10. Moeller, S.M., P.F. Jacques, and J.B. Blumberg, The potential role of dietary xanthophylls in cataract and age-related macular degeneration. *J Am Coll Nutr*, 2000. **19**(5 Suppl): p. 522S-527S.
11. Johnson, E.J., The role of carotenoids in human health. *Nutr Clin Care*, 2002. **5**(2): p. 56-65.
12. Renzi, L.M., et al., The relation between serum lipids and lutein and zeaxanthin in the serum and retina: results from cross-sectional, case-control and case study designs. *Lipids in Health and Disease*, 2012. **11**(1): p. 33.
13. Ma, L., et al., Lutein and zeaxanthin intake and the risk of age-related macular degeneration: a systematic review and meta-analysis. *British Journal of Nutrition*, 2012. **107**(3): p. 350-9.
14. Schweigert, F.J. and J. Reimann, Micronutrients and their Relevance for the Eye - Function of Lutein, Zeaxanthin and Omega-3 Fatty Acids. *Klin Monbl Augenheilkd*, 2010.
15. Stringham, J.M., et al., The Influence of Dietary Lutein and Zeaxanthin on Visual Performance. *Journal of Food Science*, 2009. **75**(1).
16. Kijlstra, A., et al., Lutein: More than just a filter for blue light. *Progress in Retinal and Eye Research*, 2012. **31**(4): p. 303-15.
17. Wang, W., et al., Effect of dietary lutein and zeaxanthin on plasma carotenoids and their transport in lipoproteins in age-related macular degeneration. *Am J Clin Nutr*, 2007. **85**(3): p. 762-9.



18. van Het Hof, K.H., et al., Dietary factors that affect the bioavailability of carotenoids. *J Nutr*, 2000. **130**(3): p. 503-6.
19. Riedl, J., et al., Some dietary fibers reduce the absorption of carotenoids in women. *J Nutr*, 1999. **129**(12): p. 2170-6.
20. Handelman, G.J., et al., Lutein and zeaxanthin concentrations in plasma after dietary supplementation with egg yolk. *Am J Clin Nutr*, 1999. **70**(2): p. 247-51.
21. Ma, L. and X.M. Lin, Effects of lutein and zeaxanthin on aspects of eye health. *J Sci Food Agric*, 2010. **90**(1): p. 2-12.
22. Hammond, B.R., Jr., et al., Dietary modification of human macular pigment density. *Invest Ophthalmol Vis Sci*, 1997. **38**(9): p. 1795-801.
23. Manzi, F., et al., The intake of carotenoids in an older Australian population: The Blue Mountains Eye Study. *Public Health Nutr*, 2002. **5**(2): p. 347-52.
24. Lyle, B.J., et al., Antioxidant intake and risk of incident age-related nuclear cataracts in the Beaver Dam Eye Study. *Am J Epidemiol*, 1999. **149**(9): p. 801-9.
25. Curran-Celentano, J.M., et al., Evaluating the influence of egg consumption as a source of macular carotenoids and the impact on serum cholesterol risk ratios. *Invest Ophthalmol Vis Sci*, 2003. **44**: p. E-abstract: 403.
26. Goodrow, E.F., et al., Consumption of One Egg Per Day Increases Serum Lutein and Zeaxanthin Concentrations in Older Adults without Altering Serum Lipid and Lipoprotein Cholesterol Concentrations. *J Nutr*, 2006. **136**(10): p. 2519-24.
27. Wenzel, A.J., et al., A 12-wk egg intervention increases serum zeaxanthin and macular pigment optical density in women. *J Nutr*, 2006. **136**(10): p. 2568-73.
28. Vishwanathan, R., et al., Consumption of 2 and 4 egg yolks/d for 5 wk increases macular pigment concentrations in older adults with low macular pigment taking cholesterol-lowering statins. *American Journal of Clinical Nutrition*, 2009. **90**(5): p. 1272-9.
29. Burns-Whitmore, B.L., et al., Effect of n-3 fatty acid enriched eggs and organic eggs on serum lutein in free-living lacto-ovo vegetarians. *European Journal of Clinical Nutrition*, 2010. **64**(11): p. 1332-7.
30. Bone, R.A., et al., Lutein and zeaxanthin dietary supplements raise macular pigment density and serum concentrations of these carotenoids in humans. *J Nutr*, 2003. **133**(4): p. 992-8.
31. Richer, S.P., et al., Randomized, double-blind, placebo-controlled study of zeaxanthin and visual function in patients with atrophic age-related macular degeneration: the Zeaxanthin and Visual Function Study (ZVF) FDA IND #78, 973. *Optometry*, 2011. **82**(11): p. 667-680 e6.
32. Weigert, G., et al., Effects of lutein supplementation on macular pigment optical density and visual acuity in patients with age-related macular degeneration. *Investigative Ophthalmology & Visual Science*, 2011. **52**(11): p. 8174-8.
33. SanGiovanni, J.P. and E.Y. Chew, The role of omega-3 long-chain polyunsaturated fatty acids in health and disease of the retina. *Prog Retin Eye Res*, 2005. **24**(1): p. 87-138.



34. Seddon, J.M., et al., Dietary fat and risk for advanced age-related macular degeneration. Arch Ophthalmol, 2001. **119**(8): p. 1191-9.
35. Mitchell, P., et al., Nutritional factors in the development of age-related eye disease. Asia Pac J Clin Nutr, 2003. **12 Suppl**: p. S5.
36. Smith, W., P. Mitchell, and S.R. Leeder, Dietary fat and fish intake and age-related maculopathy. Arch Ophthalmol, 2000. **118**(3): p. 401-4.
37. Chua, B., et al., Dietary fatty acids and the 5-year incidence of age-related maculopathy. Arch Ophthalmol, 2006. **124**(7): p. 981-6.
38. Christen, W.G., et al., Dietary {omega}-3 Fatty Acid and Fish Intake and Incident Age-Related Macular Degeneration in Women. Archives of Ophthalmology, 2011.
39. Berson, E.L., et al., omega-3 Intake and Visual Acuity in Patients With Retinitis Pigmentosa Receiving Vitamin A. Archives of Ophthalmology, 2012. [**E-pub ahead of print**].
40. European Food Safety Authority (EFSA), Scientific Opinion Docosahexaenoic acid (DHA) related health claims. EFSA Journal, 2010. **8**(10): p. 1734.
41. Vanden Langenberg, G.M., et al., Associations between antioxidant and zinc intake and the 5-year incidence of early age-related maculopathy in the Beaver Dam Eye Study. Am J Epidemiol, 1998. **148**(2): p. 204-14.
42. Schaumberg, D.A., et al., Dietary glycemic load and risk of age-related cataract. Am J Clin Nutr, 2004. **80**(2): p. 489-95.
43. Chiu, C.J., et al., Dietary carbohydrate intake and glycemic index in relation to cortical and nuclear lens opacities in the Age-Related Eye Disease Study. American Journal of Clinical Nutrition, 2006. **83**(5): p. 1177-84.
44. Chiu, C.-J., et al., Dietary glycemic index and carbohydrate in relation to early age-related macular degeneration. American Journal of Clinical Nutrition, 2006. **83**(4): p. 880-886.
45. Clemons, T.E., et al., Risk factors for the incidence of Advanced Age-Related Macular Degeneration in the Age-Related Eye Disease Study (AREDS) AREDS report no. 19. Ophthalmology, 2005. **112**(4): p. 533-9.
46. Waters, D., et al., Change in plasma lutein after egg consumption is positively associated with plasma cholesterol and lipoprotein size but negatively correlated with body size in postmenopausal women. J Nutr, 2007. **137**(4): p. 959-63.