January 23, 2020

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Docket No. FNS-2019-001

Dear Dietary Guidelines Advisory Committee:

These comments are submitted for the information of the Dietary Guidelines Advisory Committee (DGAC) by the Egg Nutrition Center (ENC). ENC is the science and nutrition education division of the American Egg Board (AEB), the research, education and promotion arm of the U.S. egg industry supported by egg farms with more than 75,000 hens. ENC is dedicated to providing objective, accurate information on the complex issues surrounding eggs, nutrition, and health. ENC sponsors scientific research that is primarily focused on egg intake and various indices of health and disease and provides science-based information to health professionals regarding the role of eggs and eggs’ nutrients in healthy diet patterns across the lifespan.

Key Points

- With consistent data linking lutein intake to eye health across the lifespan, experts have concluded that lutein should be included in dietary recommendations.
- Habitual lutein intake has been linked to measures of cognition in children and adults.
- Because of the links to human health benefits throughout the life cycle of adequate lutein consumption, science would support guidance that encouraged Americans to consume foods that are sources of lutein in the diet.
- Eggs are a complex food with macronutrients, micronutrients, and components without a recommended intake level. Additional research is needed to explore the relationship among dietary components found in eggs and the impact on health outcomes.

Lutein is a bioactive dietary component that is associated with health outcomes and ready for intake recommendations

At the October 25, 2019 Dietary Guidelines Advisory Committee public meeting, there was discussion among committee members regarding the many components in foods that are not defined as required nutrients yet might have associations with health. One of these non-essential bioactive dietary components, lutein, is associated with eye health [1] and is particularly relevant to the U.S. population that under-consumes vegetables. [2] The data connecting lutein consumption to health are so strong, a number of scientific experts have concluded lutein is ready to be considered for intake recommendations. [1]
Lutein plays an important role in eye health across the lifespan

Lutein and zeaxanthin are carotenoids found in a wide variety of fruits and vegetables, especially green leafy vegetables, as well as in eggs (Table 1). These food sources of lutein are critically important in the diet, as humans do not synthesize carotenoids. [3] Although higher amounts of lutein + zeaxanthin can be found in green leafy vegetables and supplements, lutein from enriched eggs is more bioavailable compared to spinach or dietary supplements, making eggs an important food source of this dietary component. [4]

Table 1: Lutein content of select foods [5]

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving</th>
<th>Milligrams Lutein + Zeaxanthin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kale, cooked (72119211)</td>
<td>1 cup (130 g)</td>
<td>23.5</td>
</tr>
<tr>
<td>Spinach, cooked (72125211)</td>
<td>1 cup (180 g)</td>
<td>20.2</td>
</tr>
<tr>
<td>Peas, green, cooked (75224021)</td>
<td>1 cup (160 g)</td>
<td>4.1</td>
</tr>
<tr>
<td>Spinach, raw (72125100)</td>
<td>1 cup loosely packed (25 g)</td>
<td>3.0</td>
</tr>
<tr>
<td>Broccoli, cooked (72201211)</td>
<td>1 cup chopped (184 g)</td>
<td>2.0</td>
</tr>
<tr>
<td>Brussels sprouts, cooked (75209011)</td>
<td>1 cup (155 g)</td>
<td>2.0</td>
</tr>
<tr>
<td>Romaine lettuce, raw (72116000)</td>
<td>1 cup loosely packed (35 g)</td>
<td>1.5</td>
</tr>
<tr>
<td>Corn, sweet, cooked (11770)</td>
<td>1 cup (149 g)</td>
<td>1.3</td>
</tr>
<tr>
<td>Green beans, cooked (75205021)</td>
<td>1 cup, fresh (125 g)</td>
<td>0.8</td>
</tr>
<tr>
<td>Avocado (63105010)</td>
<td>1 cup, cubes (150 g)</td>
<td>0.4</td>
</tr>
<tr>
<td>Egg, boiled or poached (31103010)</td>
<td>1 large (50 g)</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Lutein and zeaxanthin (lutein’s isomer) are selectively taken up in the macular tissue of the retina and are concentrated 100-fold higher in the central fovea, which has the highest exposure to light. [3] The concentration of lutein throughout the eye, and particularly in the central fovea, suggests it is a critical antioxidant, anti-inflammatory agent, and filter of blue light (short wavelengths). [3, 6]

The accumulation of lutein and zeaxanthin in the macula is reported as macular pigment optical density (MPOD) and can be measured with a non-invasive assessment. Several studies have found MPOD to be associated with a reduced risk of age-related macular degeneration (AMD), [3] the leading cause of vision loss for Americans aged 65 years and older. [7] Since the incidence of AMD is expected to increase by 50% by the year 2030, [8] and there are limited treatment options for end-stage AMD, diet could be a critical component of preventing this condition. [8] While MPOD response to dietary intake of lutein can be variable and might depend on genetics, gut microbiota composition, pathophysiological status, age, gender, or baseline MPOD status [9-11] for most Americans, dietary changes have the potential to improve MPOD. [12]

The role of lutein during early life is still under investigation, but there is evidence that exposure to lutein and zeaxanthin in utero can impact visual development and eye health. [12] At about 20-22 weeks gestation, lutein and zeaxanthin are diverted from the fluid reservoir of the eye into the retinal area, which corresponds to the developmental timing of the retina layers. [12] Further, lutein and
zeaxanthin continue to accumulate in the macula as a child grows, especially during the first year of life. [3] Optimal visual performance may help children interact with their environment and contribute to brain development. [6] **So, although recommendations are not yet available for pregnancy, early life, or any stage of life, “Increasing dietary lutein intake through healthy food choices could be an important public health strategy...”** [6] Increasing green leafy and yellow vegetables within energy limits is one strategy, and incorporation of eggs, a highly bioavailable food source of lutein, [4] into a healthy dietary pattern can also contribute to eye health. For example, a randomized controlled intervention trial in older adults found eating 12 eggs per week for one year resulted in significant improvements in glare recovery, a measure of macular function and retinal health. [11]

**Accumulating data link lutein to brain health throughout the lifespan**

Recent reviews have highlighted the potential role of lutein in brain health and cognitive function throughout the lifespan, starting before birth. [6, 12, 13] Although lutein is not the primary carotenoid consumed in the U.S. diet, it is the predominant carotenoid found in the human brain, accounting for ~60% of total carotenoids in the brain of full-term infants, which is approximately double the amount found in adults. [14] **This observation suggests a potential role for lutein during early life neural development.** [6, 12] New data also support a potential interaction with choline, with higher choline and lutein levels in human milk related to better recognition memory in six-month old infants, similar to the relationship found with choline and DHA. These data demonstrate, “Nutrients do not exist in isolation nor is consumption limited to one type of food. Thus, nutrients may work synergistically in the brain.” [15]

Accumulating data link Macular Pigment Optical Density (MPOD), an indicator of lutein and zeaxanthin in neural tissues, [16] with measures of cognitive function in children. Four recent cross-sectional studies were summarized by Stringham et al. which consistently demonstrate a positive association between MPOD and measures of cognition or academic achievement in children. [12, 14, 17-19] **Interestingly, while the first 1000 days is known to be a critical period for brain development, [20] the preadolescent/adolescent age group is also a particularly vulnerable period for brain development, with rapid synaptogenesis and pruning starting ~10-11 years of age.** [12, 21] The role of lutein in the brain during development is hypothesized to be related to its ability to protect against oxidative stress, modulate membrane stability, and/or enhance neuronal communication. [12]

Further, the potential beneficial role of “…carotenoids within the central nervous system may be evident during early and middle adulthood, decades prior to the onset of older age.” [22] In one study, MPOD was related to select measures of cognitive control in 25 to 45-year-old individuals. [22] This is consistent with **data in older adults demonstrating higher MPOD is correlated with better cognitive performance.** [23] One study in healthy women aged 60-80 years found supplementation with 12 mg lutein per day for four months, with or without 800 mg DHA/day, improved verbal fluency scores. [24] These data support that there may be health benefits of consuming higher amounts of lutein across the lifespan, which can be achieved through careful selection of foods within a healthy dietary pattern. [6, 12]
Interaction of nutrient and non-nutrient components in eggs are being explored for their relationship to health

Approximately 28% of the total lipids in a chicken egg are phospholipids, [25] primarily as phosphatidylcholine, phosphatidylethanolamine, sphingomyelin, phosphatidylinositol, and lysophosphatidylcholine. [26] These dietary phospholipids potentially impact markers of inflammation, cholesterol absorption and metabolism, and HDL function. [27] For example, human interventions studies have demonstrated that consumption of eggs can increase plasma HDL cholesterol [27] and improve HDL function, as measured by cholesterol efflux capacity. [27-29] This preliminary research is an area of high interest, as cholesterol efflux capacity is predictor of heart disease status. [27, 30]

Egg proteins also are being explored for their impact on health beyond provision of amino acids. “Several biological activities have now been associated with egg components, including novel antimicrobial activities, antiadhesive properties, immunomodulatory, anticancer, and antihypertensive activities, antioxidant properties, protease inhibitors, nutrient bioavailability, and functional lipids, highlighting the importance of egg and egg components in human health and in disease prevention and treatment.” [25] Animal studies document a vasorelaxing impact of certain egg white-derived peptides, and combined with potential antioxidant properties, could be of particular interest in cardiovascular health. [25] These observations are consistent with existing reviews consisting of both prospective cohort studies and intervention studies demonstrating a negative association between egg intake and risk of hypertension. [31]

Finally, recent data suggest that the associations of egg consumption on health outcomes and components within eggs may be a result of nutrient interactions. [24] One study found higher human milk choline levels with higher lutein levels, as well as higher choline with higher DHA levels, were associated with better recognition memory in 6-month old infants. The authors concluded, “Interactions between human milk nutrients appear important in predicting infant cognition, and there may be a benefit to specific nutrient combinations.” [15] These observations support a need for further research examining the impact of how, “nutrients that lurk together work together” [32] in eggs and all foods.

These new data consider the impact of the whole egg, and align with The National Academy of Medicine’s recommendations for the evaluation process for biomarkers, with focus on biomarkers and surrogate endpoints in chronic disease. [33] This report states, “The differing health effects of individual nutrients or other food substances are important. Due to this, **for foods, focusing on a single nutrient or food substance contained in a food or in several different foods can be misleading because it fails to take into account potential modifying effects of the source of the substance and matrix effects of other components in the food**, meal, and diet...the modifications of the substance’s effect on the disease outcome by other bioactive components in that food or the diet.”
Conclusion: Eggs are a bioavailable food source of lutein, a carotenoid strongly linked to health outcomes across the lifespan

- MPOD is an indicator of habitual lutein intake measured in the retina and reflects the level of lutein and zeaxanthin in neural tissues.
- Several studies have shown increased MPOD is associated with a reduced risk of AMD, the leading cause of vision loss for Americans aged 65 years and older.
- Accumulating data highlight the potential role of lutein in brain health and cognitive function throughout the lifespan, starting before birth.
- Current data support that there are health benefits associated with consumption of higher levels of lutein, which can be achieved through careful selection of foods within a healthy dietary pattern.
- There is a need for additional research on the impact of dietary components within eggs, including lutein + zeaxanthin, phospholipids, proteins, and interaction with nutrients for their impact on health outcomes.

While lutein does not yet have a Dietary Reference Intake (DRI), the evidence for lutein’s importance to health is substantial. Previous editions of the DGA contain numerous recommendations that do not correspond directly to a particular DRI – for example, advice to consume ‘nutrient-dense foods’ and to consume a variety of vegetables from all of the subgroups, including ‘dark green’ vegetables. In a similar way, if the DGAC wished to recognize the science that supports a focus on lutein, a recommendation to consume lutein-containing foods would be a means of doing so.

American Egg Board’s Egg Nutrition Center appreciates the opportunity to provide this information to the DGAC.

Sincerely,

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References


