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ABSTRACTS

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POSTER ABSTRACTS

(MC001)
NUTRITIONAL PATTERNS, MACULAR PIGMENT AND AGE-RELATED MACULAR DEGENERATION (AMD) IN THE PAMDI POPULATION OF THE MEDITERRANEAN BASIN

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Purpose: To evaluate the association of nutritional patterns and macular pigment (MP) level with the prevalence of different severity grades of age-related macular degeneration (AMD) in a population of the Mediterranean basin.
Methods: Food consumption data were collected at enrollment by using a food frequency questionnaire. Foods were grouped in 4 classes: protective (PF), risky (RF), lutein-rich (LR), and neutral (NF). Macular pigment (MP) level was measured by resonance Raman spectroscopy (RS) in a representative sample of 220 patients. Color fundus photography images were taken and graded for characteristics of AMD at the Moorfields Reading Centre. A multivariate logistic analysis evaluated the correlation of these factors with the different grades of AMD.
Results: In the cohort of 824 patients, the intake of PF resulted in significant reduction in odds ratios for the development of large drusen (OR 0.95, CI 0.92-0.98, p = 0.008), more significantly so in the rural cohort (OR 0.93, CI 0.89-0.97, p = 0.0002). The 2 highest quartiles of PF and the 2 lowest of RF were associated with lower risk of large drusen (OR 0.72, CI 0.59-0.88, p = 0.0013; OR 1.23, CI 1.02-1.48, p = 0.0274, respectively). LR and NF were not associated with any stages of AMD. The mean level of MP was 955.1. There was a significant association between MP and the severity of the disease, especially in the advanced stages (p<0.0001). No association between MP levels and dietary pattern was found.
Conclusions: Although in the current study the level of MP did not show significant relation to diet, it did to AMD. Protective food intake was associated with reduced risk for large drusen.

(MC002)
IMPACT OF ZEAXANTHIN CONCENTRATION ON ITS BIOACCESSIBILITY IN BIOFORTIFIED SWEET CORN

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Purpose: To evaluate the bioaccessibility of zeaxanthin and lutein from a zeaxanthin-biofortified sweet corn (HZ23-1) and a standard commercial yellow sweet-corn (Garrison).
Methods: Carotenoid bioaccessibility from microwave-cooked sweet-corn kernels of HZ23-1 (11.8 mg zeaxanthin/kg FW) and Garrison (2.4 mg zeaxanthin/kg FW) was assessed by an *in vitro* digestion model mimicking the gastric and small intestinal digestion process. Carotenoid concentrations were determined by HPLC.
Results: Relative bioaccessibility of zeaxanthin and lutein in biofortified and commercial kernels was generally similar, ranging from 29% to 35%. However, an elevated zeaxanthin bioaccessibility (64%) was observed in the commercial yellow kernels. Despite this higher relative bioaccessibility, the absolute release of zeaxanthin (1.5 mg/kg FW) was significantly (p<0.05) lower than that released by the zeaxanthin-biofortified kernels (3.4 mg/kg FW).
Conclusions: The question as to why zeaxanthin relative bioaccessibility was higher in the commercial hybrid Garrison remains unanswered. It is possible that a lower initial zeaxanthin concentration (<2.4 mg/kg FW) may reduce its degree of binding to endosperm cellular components such as zein, a maize storage protein known to sequester lutein and zeaxanthin.
Disclosures: None.

(MC003)
TWEAKING NATURE: ZEAXANTHIN AND LUTEIN CONCENTRATION IN SWEET CORN CAN BE MODIFIED BY GENOTYPE, PHYSIOLOGIC MATURITY, AND LOCATION ON THE COB

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Purpose: Identification to what extent zeaxanthin and lutein concentration can vary in zeaxanthin-biofortified and standard yellow sweet corn kernels by altering physiologic maturity of the cob and what part on the cob is selected for consumption.
Methods: Cobs of zeaxanthin-biofortified and a standard yellow sweet corn hybrid were harvested at increasing stages of edible physiologic maturity (14-29 days after pollination) ranging from early-mature (pale, tender) to late-mature (deeply colored, tough). Xanthophyll profiles of kernels selected from the basal, middle and tip-end of each cob were analyzed by HPLC, along with maturity parameters, sweetness (total soluble solids) and moisture content (%).
Results: Relative proportions of zeaxanthin and lutein were largely determined by plant genotype, with the zeaxanthin-biofortified hybrid predominating in zeaxanthin (20:1 Z/L), and the standard yellow hybrid in lutein (1:2 Z/L). Physiologic maturity had a significant impact on total carotenoid synthesis, with the zeaxanthin-biofortified hybrid increasing in zeaxanthin-concentration ninefold, and the standard yellow hybrid increasing in lutein twofold as kernel maturity increased. Kernels towards the tip-end of the cobs had the highest concentration of zeaxanthin and lutein, followed by kernels from the middle. Basal kernels had the lowest concentration.
Conclusions: Zeaxanthin and lutein concentration in sweet-corn is determined by a combination of genotype and physiologic maturity. Genotype largely controls the relative proportion of xanthophylls, while physiologic maturity is tightly linked to their accumulation. The cob is not homogeneous, such that kernels at the tip-end contain higher concentrations of lutein and zeaxanthin.
Disclosures: None.

(MC004)
FLUORESCENCE-LIFETIME-IMAGING-OPHTHALMOSCOPY (FLIO) OF CAROTENOID FLUORESCENCE *IN VIVO*

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Purpose: Macular pigment (MP) attenuates the fundus autofluorescence (FAF) by absorbing short-wavelength excitation light. *In vitro*, lutein and zeaxanthin show a very short fluorescence lifetime of ca. 200-250 fs. This study investigated if MP has an influence on the FAF lifetime by using FLIO.
Methods: Time-resolved FAF decays have been recorded for 32 subjects with full-thickness idiopathic macular holes (MH) and 20 subjects with macular

pseudoholes (MPH), using a prototype FLIO device (Heidelberg Engineering, Germany). A healthy collateral eye (CE) was recorded for 13 MH. FAF decays were measured in 2 spectral channels (ch1: 498-560 nm; ch2: 560-720 nm) and approximated by a sum of 3 exponentials, resulting in 3 lifetimes: τ1, τ2, and τ3. Their amplitude-weighted mean (τM) was utilized for statistical analysis. τM averaged over the MH was compared to the para-MH region (PMHR) and fovea in CE (*t* test). MP (optical density) was measured with a fundus camera (VisuCam, Zeiss Meditec Inc.).
Results: For MH (without operculum), τM was longer for the MH (ch1: 226 ± 13 ps; ch2: 263 ± 9 ps) compared to the PMHR (ch1: 176 ± 15 ps; ch2: 217 ± 8 ps); p<0.001. Shortest τM can be assigned to areas with highest MP. τM of the MH was longer than in CE (p<0.05). For MPH, only the presence of MP-containing layers led to short macular lifetimes.
Conclusions: Fluorescence lifetimes are found to be shortest in the macular region of healthy eyes. Whether the retinal layers containing MP were intact or affected by the MH determined the presence of short foveal τM. A significant negative correlation of τM to MP in healthy young subjects was found in a previous study. Thus, short foveal τM are most probably caused by MP.
Disclosure: No financial disclosures.

(MC005)
CHILDHOOD VEGETABLE INTAKE PREDICTS ADULT MACULAR PIGMENT OPTICAL DENSITY
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Purpose: To determine the relative contribution of childhood (ages 2-13) versus adolescent/young adult (ages 14-23) vegetable intake on current macular pigment optical density (MPOD).
Methods: Childhood and young adult vegetable intake was determined via self-report questionnaire in 83 college-aged subjects (47 female/36 male) from the University of Georgia. MPOD was measured at 30° retinal eccentricity via customized heterochromatic flicker photometry.
Results: Mean MPOD in our sample was 0.51. Childhood vegetable intake was significantly associated with subjects' MPOD (r = 0.42; p<0.001), whereas young adult vegetable intake showed virtually no association (r = 0.05; p = 0.71). To more closely examine the effects of childhood diet, MPOD was stratified into low (0-0.35), medium (0.36-0.70) and high (>0.70) groups. A one-way ANOVA with Tukey post hoc analysis showed that those subjects with low MPOD consumed significantly fewer vegetables (mean = 4.59 on 1-10 scale) as children than those with medium (mean = 6.15) or high (7.13) MPOD (F = 7.80; p<0.001).
Conclusions: One possible explanation for the results of this study is that, compared to adolescence/early adulthood, lutein and zeaxanthin are more readily absorbed and deposited in retinal tissue during relatively early, developmental years. This may be advantageous, given the increased metabolism and potential for oxidative stress in developing tissues. It could also be possible that the relationship between childhood diet and MPOD is accounted for by more consistent (and higher) vegetable intake during a time in life when diet is largely determined by parents.
Disclosures: Funding provided by Fight for Sight (FFS-SS-13-011) and Omniactive Health Technologies, Inc.

(MC006)
EFFECT OF DIVALENT MINERALS ON THE BIOACCESSIBILITY OF LUTEIN AND OTHER CAROTENOIDS
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Purpose: Several dietary factors are known to affect the bioaccessibility (BA) of carotenoids including lutein (Lut). One factor that so far has been neglected is the influence of divalent minerals (DM) on the micellarization of carotenoids during gastrointestinal digestion (GI). Our previous research indicated that DM reduced the BA and Caco-2 cellular uptake of carotenoids from spinach, though the effects have never been studied systematically and with individual carotenoids. We hypothesize that high concentrations of DM lead to the formation of insoluble soap complexes, hampering carotenoid BA.
Methods: We investigated the effect of varying physiologic concentrations (0-1000 mg/L) of calcium, magnesium, and zinc on the BA of Lut, neoxanthin, lycopene, and β-carotene following *in vitro* GI. BA measures were further coupled with rheologic measurements of the digested fluids.
Results: Addition of DM significantly decreased (p<0.05) the BA of Lut and other carotenoids, up to 100% in the case of calcium. We also observed the formation of insoluble complexes during GI. Increased DM concentrations were correlated to decreased viscosity (r>0.9) and decreased carotenoid BA. Surface tension of digesta was inversely correlated (p<0.05) with the BA of carotenes.
Conclusions: Although based on *in vitro* findings, it is plausible that similar interactions occur *in vivo*, with DM affecting the BA and bioavailability of carotenoids and other liposoluble micronutrients.

(MC007)
THE RELATIONSHIP BETWEEN MACULAR PIGMENT OPTICAL DENSITY AND COGNITIVE FUNCTION IN THE CREST STUDY
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Purpose: Macular pigment (MP) found at the central retina (macula) is comprised of the carotenoids lutein (L), zeaxanthin (Z), and meso-zeaxanthin (MZ). MP levels correlate with brain concentrations of L and Z, and have also been shown to correlate with cognitive performance in the young and elderly. This study investigated the relationship between MP and cognitive function (CF) using subjects enrolled in the Central Retinal Enrichment Supplementation Study (CREST).
Methods: CREST is a double-blind, parallel-group, and randomized controlled clinical trial, which is studying the impact of macular carotenoid supplementation (with L, Z, and MZ) on visual function and CF. The subjects studied in CREST included individuals free of retinal disease with low MP (group 1, n = 105) and subjects with early age-related macular degeneration (AMD) (group 2, n = 121). We present the baseline findings. MP was measured using customized heterochromatic flicker photometry and dual-wavelength autofluorescence. CF was assessed using the CANTAB battery of validated cognition tests.
Results: Significant correlations were evident between MP and various measures of CF in both groups (r = −0.273 to 0.261, p<0.05, for all). Higher levels of MP were associated with better performance in CF tests measuring top-down cognitive processes involving the prefrontal cortex, tests assessing visual memory, and tests examining both new and verbal learning. All correlations, with the exception of the verbal learning and memory in the low MP group and semantic fluency in the AMD group, remained statistically significant after controlling for age, sex, diet and education level (p≤0.05, for all).
Conclusions: As MP is positively related to CF in subjects free of retinal disease and in subjects with AMD, it may have potential as a noninvasive clinical biomarker of cognitive health.

(MC008)
NON-DIETARY DETERMINANTS OF PLASMA LUTEIN AND ZEAXANTHIN CONCENTRATIONS IN THE IRISH POPULATION
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Purpose: To investigate nondietary determinants of plasma lutein (L) and zeaxanthin (Z) concentrations in The Irish Longitudinal Study on Ageing (TILDA).
Methods: TILDA is a prospective cohort study of community dwelling adults aged 50 and over in Ireland. Blood samples collected at Wave 1 of the study were analyzed for plasma concentrations of L and Z by reversed-phase high

performance liquid chromatography and macular pigment (MP) optical density was measured using customized heterochromatic flicker photometry. Demographic and health variables were also collected.
Results: After excluding subjects with any eye disease, data from 3,681 participants were available for analysis. For this group of subjects, L and Z were negatively and significantly associated with BMI, and were positively and significantly associated with MP, total cholesterol, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) ($p<0.001$). L and Z were significantly lower in males, current smokers, subjects reporting less physical exercise, and subjects with lower education ($p<0.05$). L was significantly higher in subject reporting a family history of AMD, and in the group ≥75 years old ($p<0.05$). For each of these variables, the significant associations remained after controlling for the other variables.
Conclusions: This large study, the first of its kind in Republic of Ireland, is consistent with most of the findings from earlier published studies reporting on nondietary determinants of plasma L and Z. Also, this study confirms that cigarette smoking, the only modifiable established risk factor of age-related macular degeneration, is associated with lack of circulating plasma L and Z.
Disclosures: Stephen Beatty and John Nolan are Directors of Nutrasight Consultancy Ltd., where they do consultancy work for companies with an interest in supplements for eye care. The other authors report no potential conflict of interest. This work was supported by Bayer, Ireland, and Waterford Institute of Technology Presidential Scholarship. TILDA is funded by the Irish Government, Atlantic Philanthropies, and Irish Life plc.

(MC009)
AMERICAN DIETARY PATTERNS AND AGE-RELATED MACULAR DEGENERATION
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Purpose: The objective of this study is to evaluate the inter-relationship between American major and minor dietary patterns and their associations with age-related macular degeneration (AMD) risk.
Methods: 8,103 eyes from 4,088 eligible participants in the baseline Age-Related Eye Disease Study (AREDS) were classified into control (n = 2,739), early AMD (n = 4,599), and advanced AMD (n = 765) according to the AREDS AMD Classification System. In addition to the 2 major dietary patterns (Oriental and Western) described previously, 8 minor patterns were characterized by principal component analysis (PCA) on dietary consumption data of 37 food groups. Qualitative comparative analysis (QCA) was used to evaluate the inter-relationship between patterns. Applying the generalized estimation equation in logistic models, we related the 8 minor patterns to the prevalence of AMD.
Results: In general, the 8 minors were subsets or extensions of either Oriental or Western pattern and consisted of fewer characteristic foods than the 2 majors. Unlike the 2 majors, which were stronger associated with both early and advanced AMD, none of the 8 minors was associated with early AMD and only 4 minors, including Steak pattern (odds ratio [OR] comparing the highest to lowest quintile of the pattern score = 1.73 [95% confidence interval: 1.24 to 2.41; p trend = 0.02]), Breakfast pattern (0.60 [0.44 to 0.82; p trend = 0.004]), Caribbean pattern (0.64 [0.47 to 0.89; p trend = 0.009]), and Peanut pattern (0.64 [0.46 to 0.89; p trend = 0.03]), were significantly associated with advanced AMD. Our data also suggested several potential beneficial/harmful foods for AMD, such as peanut, pizza, salad dressings, coffee, or tea.
Conclusions: Our findings suggest that a diet consisted of various healthy foods may be the optimal diet for reducing AMD risk and that the effects of some specific foods in the context of overall diet warrant further study.
Disclosures: Financial support for this project has been provided by RO-1EY021826 (C.-J.C.) from the National Institutes of Health, the United States Department of Agriculture under agreements 1950-5100-060-01A (C.-J.C., A.T.), RO1EY013250, and RO1EY021212 (A.T.). Design and conduct of the study (C.-J.C., A.T.); collection, management, analysis, and interpretation of the data (C.-J.C., M-L.C., T.L., G.G.); preparation, review, or approval of the manuscript (C.-J.C., M-L.C., T.L., G.G., A.T.); statistical expertise (C.-J.C., T.L., G.G.); administrative, technical, or logistic support (M.-L.C., G.G.). Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views or policies of the United States Department of Agriculture, nor does mention of trade names, commercial products, or organizations imply endorsement by the United States Government. The funding sources had no role in the design and conduct of the study; the collection, analysis, and interpretation of the data; or the preparation, review, or approval of the manuscript. The authors declare no conflict of interest.

(MC010)
A SINGLE CASE OF SPONTANEOUS MACULAR HOLE CLOSURE IN MACULAR TELANGIECTASIA TYPE 2 FOLLOWING NUTRITIONAL SUPPLEMENTATION
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Purpose: To document the occurrence of spontaneous macular hole closure in a patient with macular telangiectasia type 2 that was using ocular nutritional supplementation.
Methods: A 67 year old male presented with a history of decreased vision in the left eye for 6 months. Examination revealed a visual acuity of 20/80 in the left eye and a full-thickness macular hole. Visual acuity in the right eye was 20/40 with a cavitation that was consistent with macular telangiectasia type 2. The patient elected nonsurgical management and commenced ocular nutritional supplementation (MacuHealth LMZ3).
Results: Visual acuity in the left eye deteriorated over 9 months to 20/400, following which there was complete closure of the macular hole and subjective improvement in visual acuity at 20 months. Final visual acuity following closure of the hole was 20/80. The clinical findings in the right eye remained unchanged.
Conclusions: Macular telangiectasia type 2 is a complex degenerative disease with an unresolved etiology. Macular pigmentary changes is a common manifestation of this disease and strategies to replenish macular pigments, through nutritional supplementation, may be useful in the management of this disease. Larger studies will be required to validate this hypothesis.

(MC011)
EFFECTS OF PHOSPHOLIPIDS ON THE LYMPHATIC ABSORPTION OF LUTEIN AND DHA IN RATS
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Purpose: Determine if the addition of different proportions of phospholipids, lecithins, to an oil mixture improves the intestinal absorption of lipophilic compounds of interest like lutein, DHA, or tocopherols in rats.
Methods: The lymph fistula rat model was used to study the intestinal absorption of lipids in 4 experimental groups (n = 6 male rats/group). The oil mixtures to study were: high oleic sunflower oil (HOSO) (group 1), a mixture of lutein, DHA, RRR-tocopherol in HOSO oil (group 2), the same mixture in which HOSO was partially substituted by soy lecithins (group 3), the same mixture in which all the HOSO was substituted by soy lecithins (group 4). Animals received 1 mL of the corresponding oil mixture by oral gavage. Lymph and serum samples were collected at 4 cutoff points to measure basal levels and concentrations at several times after the oral gavage. Lutein and tocopherols contents, as well as lipid profile of biological samples, were determined by UPLC-MS/MS. DHA concentration in lymph was analyzed by GC.
Results: The cumulative amount of lutein and DHA in lymph was higher in group 4 when compared to the other groups. Oil mixtures 2, 3, and 4 increased the serum lutein concentrations even when the lymphatic duct was cannulated. Lymph samples of group 3 and 4 tended to have higher concentration of phosphatidylcholine-DHA (PC-DHA).
Conclusions: The presence of lecithin increased the absorption of lutein and DHA and favored the formation of PC-DHA that can be the preferred source of DHA for the brain. Moreover, the addition of phospholipids might partially shift the absorption of lutein from the lymphatic system to the portal vein.
Disclosures: All authors are employees of Abbott Laboratories.

(MC012)
A PROSPECTIVE STUDY OF NEUROCOGNITIVE ENHANCEMENT WITH CAROTENOIDS IN ELDERLY ADULT MALES WITH EARLY AGE-RELATED MACULAR DEGENERATION: THE ZVF STUDY GROUP (FDA IND #78,973)
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Background: Diets rich in carotenoids may reduce cognitive impairment. Little is known about dietary zeaxanthin.
Objective: To evaluate zeaxanthin carotenoid supplementation against change in cognitive status.
Methods: American Psychological Association (APA) certified cognitive evaluation from the Zeaxanthin and Vision Function Study (US FDA Investigative New Drug IND #78,973), a 1-year prospective randomized controlled trial (RCT) of elderly males with mild age-related macular degeneration. Neurocognitive testing: Repeatable Battery for the Assessment of Neuropsychological Status Update RBANS and Trail Making A & B. Subjects evaluated at baseline and 1 year after dietary isomer RR zeaxanthin (8 mg/d) alone or combined with lutein (9 mg/d) using one-way ANOVA ($p<0.05$) and t testing.
Results: Fifty subjects completed both study visits. Delayed memory in the zeaxanthin group improved from RBANS score of 91.8 (SD 16) to 99.4 (SD 12), $p = 0.04$.
Conclusions: Zeaxanthin, typically minimally present in the US diet, may nonetheless be important in the context of emerging relationships in primates between xanthophyll carotenoids and cognitive function. Additional larger scale RCTs is indicated to investigate the clinical utility of this carotenoid in nutritional neuroscience.
Disclosures: Global Scientific Director, Zeaxanthin Trade Association (SR).

(MC013)
PHYSICOCHEMICAL PROPERTIES OF LUTEIN MICROENCAPSULATION AND ITS INFLUENCE ON THE BIOAVAILABILITY OF LUTEIN
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Purpose: Many studies have focused on the preparation of lutein microencapsulation (LM), while little has been reported on its physicochemical properties (PP) and bioavailability (BA). PP and BA, which are very important for the final application of LM, have some internal relations. This paper was to investigate the PP of LM, which was prepared with advanced spray and starch-catching drying technology, and to assess its BA as well as to discuss the influence of PP to BA.
Methods: PP including its normal particle characterization, storage stability together with dissolution were evaluated. The BA was performed using SD rats following a single oral administration of lutein equivalent to 100 mg, and was compared with commercial reference sample (RS).
Results: LM was nearly sphericity and can be free-flowing. It can disperse in water to form a homogeneous dispersion with its mean particle size as 214.7 nm. The storage stability of lutein was enhanced significantly under both accelerated and long-term storage conditions. More than 85% lutein could be released from LM after 15 min during the dissolution test. The relative BA of lutein was 139.1% in comparison to RS.
Conclusions: LM has good stability, good solubility and small mean particle size in water solution, which led to higher BA related to reference. The relative BA study in rats demonstrated the good ability of LM to enhance the BA of lutein.

(MC014)
LUTEIN PROTECTS MÜLLER CELLS FROM HYPOXIC CELL DEATH BY ITS ANTI-AUTOPHAGIC PROPERTY
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Purpose: Our earlier studies showed that lutein, a macular carotenoid, protected the retina from ischemia/reperfusion injury by its anti-oxidative, anti-apoptotic and anti-inflammatory properties. We aim to investigate the anti-autophagic effect of lutein-mediated protection in a cultured retinal glial cell line.
Methods: Cultured rat Müller cells (rMC-1) were exposed to cobalt (II) chloride ($CoCl_2$) together with lutein or vehicle for different time periods. Cell viability and cell death were determined by MTS and LDH assays, respectively. Expression of an autophagic marker, microtubule-associated protein light chain 3 (LC3), was assessed by Western blot. The autophagic vesicles were examined by Cyto-ID® Autophagy Detection Kit.
Result: Lutein treatment was able to improve cell viability and reduce LDH release after the 24-hour $CoCl_2$-induced hypoxia in rMC-1 cells. Western blot analysis showed that lutein was able to attenuate expression of LC3 upon $CoCl_2$- and rapamycin-induced autophagy, respectively. Moreover, percentage of cells with autophagic vesicle was decreased in lutein-treated rMC-1 cells upon $CoCl_2$ treatment.
Conclusions: Lutein rescues Müller cells after hypoxia and its protective role in autophagy is possibly involved in mTOR-dependent pathway.

(MC015)
CAROTENOID ACCRETION IN NEONATAL RATS AND PIGLETS
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Purpose: We explored the feasibility of using rat or pig animal models for characterizing carotenoid accretion in tissues, particularly eye and brain, during development.
Methods: Brain, liver, and stomach milk were collected from rat pups at age 21 days (P21) nursed by dams fed diets with or without carotenoid supplementation. In addition, eye tissues were collected from weaned pups at P21, and again at 6 months after reintroduction to the carotenoid diet for 1 month. For piglets, serum was collected at P0 and P49 and brain tissue at P49. Sow's milk was collected at P0 and P7. Carotenoid analysis was performed by HPLC.
Results: While levels of isolutein, β-carotene, cryptoxanthin, and lycopene were higher in the stomach contents of pups from carotenoid-supplemented dams, lutein, zeaxanthin, cryptoxanthin, and α-carotene levels were not different. Liver samples from carotenoid-supplemented pups contained higher levels of lutein, α-carotene, β-carotene, and lycopene than controls. While unaffected by diet, lutein and zeaxanthin were detected in eyes of pups at P21 but were undetectable at 6 months. No carotenoids were found in rat brain. In piglet hippocampus and frontal cortex, cryptoxanthin and α-carotene were the only carotenoids detected. Similarly, iso-cryptoxanthin and α-carotene were the only carotenoids detected in sow's milk. Surprisingly, no carotenoids were detected in piglet serum.
Conclusions: Carotenoid supplementation of rat dams did not impact carotenoid levels in eye or brain of pups, and low levels of specific carotenoids were found in piglet brain. Carotenoid accretion is limited in eye and brain of rat pups and piglets. These animal models are therefore not useful for the study of most carotenoids in neural tissues.
Disclosures: M. Ramirez, M. Camprubi-Robles, A. Barranco, J.C. Lieblein-Boff, M.J. Kuchan, and C.S. Lai are employed by Abbott Nutrition.

(MC016)
ENRICHMENT OF YOLKS WITH ZEAXANTHIN AND Β-CRYPTOXANTHIN FROM CHINESE LANTERN (*PHYSALIS ALKEKENGI VAR. FRANCHETII*)
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Purpose: The calices and berries of Chinese lantern (*Physalis alkekengi var. franchetii*), a well-known ornamental plant, are a rich source of macular carotenoid zeaxanthin and β-cryptoxanthin, a provitamin A xanthophyll. The purpose of our work was to produce eggs enriched with zeaxanthin and β-cryptoxanthin using this plant.
Methods: A study on 30 laying hens transferred to individual cages was performed in 4 weeks. One group of 5 hens served as a control, getting practically no carotenoids in their diet. After the first 2 weeks of a cleansing phase

without carotenoids in the feeding the 5 groups of hens were getting feed containing up to 2% of the dried and ground calices and berries of Chinese lantern for another 2 weeks.
Results: The maximum content of xanthophylls in yolks was achieved after 10 days from the beginning of feeding with carotenoids from Chinese lantern. The average content of the all-(E)-zeaxanthin in the control eggs was 40 µg/egg and the maximum content was 523 µg/egg (average 430 µg/egg). The average content of β-cryptoxanthin raised from 5 µg/egg in the control to 123 µg/egg.
Conclusions: The Chinese lantern plant (*Physalis alkekengi var. franchetii*) has potential for production of zeaxanthin and β-cryptoxanthin.

(MC017)
SOLUBLE LUTEIN INHIBITS CHOLINESTERASE AND REDUCES ULTRAVIOLET RADIATION-INDUCED INFLAMMATION AND IMMUNOSUPPRESSION: *IN VITRO* MODEL
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Abstract: Exposure to solar ultraviolet (UV) radiation is believed to increase oxidative stress and may cause oxidative damage to retinal pigment epithelial (RPE) cells. Ultraviolet light triggers a number of deleterious cellular responses in retinal cells that lead to changes in gene and protein expression. Lutein and zeaxanthin isomers (R-R and R-S) are carotenoids that play a functional role in the macula and retina of the eye. Optimal levels of lutein and zeaxanthin isomers (L/Zi) may reduce the risk of macular degeneration, due in large part to their antioxidant properties and ability to absorb light within the UV range.
Purpose: This study is to evaluate soluble lutein (Lutemax 2020®) effect on cholinesterase activity, antioxidant enzymes and in response to ultraviolet (UV) irradiation in an *in vitro* model.
Methods: Retinal pigment epithelial (RPE) cells play a key protective role by shielding the retina from damaging UV rays, and are used as a model to study the effect of therapeutic interventions. In another study, a human RPE cell line (ARPE-19) was either mock treated or given L/Zi for 24 hours prior to mild UV irradiation (100 µJ/cm^2 for 7 seconds). Cells were maintained for another 18 hours, then harvested for gene expression, cytokine gene expression (qPCR), cytokine protein levels (protein array chip), and alteration in antioxidant enzyme activity.
Results: In an *in vitro* model, L/Zi treatment inhibited cholinesterase activity and enhanced catalase activity. These results suggest inhibition of cholinesterase enzyme and enhancing antioxidant enzymes may have several therapeutic applications such as neurodegeneration disorders and myasthenia gravis. Mild UV irradiation affected significant changes in 545 genes, including downregulation of c-SRC and β-catenin, and upregulation of VEGF and FOXO-3A. In this study, low concentration of L/Zi (10 mcg) demonstrated effects on the genes related to VEGF, FOXO etc. L/Zi induced changes in 520 genes, most notably downregulation of β-catenin, and upregulation of specific G-protein constituents that support neurophysiologic processes in vision and enhanced immune system poise. L/Zi supplemented cells were mild UV irradiated, 573 genes were significantly affected, most notably an upregulation of c-SRC. There were changes in cytokine gene expression and enhanced SOD and GPx.
Conclusions: L/Zi treated cells may ameliorate the effects of mild UV irradiation on RPE cells, as shown by expression of genes involved in cell proliferation, inflammation, immune function and wound healing.
Disclosures: Employee at OmniActive Health Technologies Inc.; the primary author works for professional societies committees (Women and Diabetes, American Diabetes Association, Academy of Nutrition and Dietetics and American Society of Nutritional Sciences, American College of Nutrition).

(MC018)
THE EFFECTS OF ANTI-BLUE LIGHT LENSES ON VISUAL AND BIOLOGICAL FUNCTION
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Purpose: To investigate the effects of wearing anti-blue light lenses on macular pigment optical density (MPOD), color vision (CV), contrast sensitivity (CS), and sleep quality.
Methods: Two groups of healthy Chinese adults (age 18-30 years, n = 22; 40-55 years, n = 29) were recruited. Each participant was required to wear 3 pairs of spectacle lenses, each for one month, with identical prescriptions in random order: (1) clear lens with anti-reflective coating; (2) clear lens with anti-blue light reflective coating, and (3) 10% brown-tint lens with anti-reflective coating. The effects of lens wear on MPOD, CV, CS with and without glare were measured by a macular pigment screener (Elektron Tech., US), the Farnsworth-Munsell 100 hue test, and the Mars CS test, respectively. Sleep quality after wearing each pair of lenses for one month was evaluated using questionnaires.
Results: According to the guidelines on blue light hazards (ICNIRP), the 2 anti-blue light lenses 2 & 3 provide an approximately 14%-20% reduction in the relative retinal phototoxicity (wavelength: 320 to 700 nm) when compared to lens 1. In general, wearing anti-blue light lenses had no significant impacts on MPOD, CV, and CS in both with-glare and without-glare conditions (2-way ANOVA repeated measures, all $p>0.40$), and did not affect the quality of sleep (Kruskal-Wallis test, all $p>0.08$). Interestingly, the mean MPOD (0.51 ± 0.19) in our Chinese participants was found to be higher than that reported previously in other ethnic groups.
Conclusions: The anti-blue light lenses, which partially filter out the short-wavelength light without altering CV, CS and sleep quality, may be considered as a supplementary option for protecting retina from potential blue-light hazard.
Disclosures: This project is supported by Swiss Lens Laboratory (HK) Limited in the form of research funding and spectacle lenses.

(MC019)
ASSESSMENT OF LUTEIN, ZEAXANTHIN, AND MESO-ZEAXANTHIN CONCENTRATIONS IN DIETARY SUPPLEMENTS BY CHIRAL HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY
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Purpose: To analyze lutein (L), zeaxanthin (Z), and meso-zeaxanthin (MZ) concentrations in a sample of commercially available macular carotenoid supplements, in order to assess concordance to their label claim.
Methods: For 9 different carotenoid supplements, we sourced 3 different batches of each supplement, and measured L, Z, and MZ concentrations using chiral high-performance liquid chromatography-diode array (HPLC-DAD).
Results: For L, 7 of the products tested contained at least 100% of L claimed on the product label (104% to 121%), with 2 products containing less than 100% of the L declared on their label (95% and 99%); however, for both of these products the 95% confidence intervals did include 100%. For Z, 5 of the products tested contained at least 100% of their label claim (109% to 248%), whereas 3 products contained less Z than declared on their label (60%, 47%, and 52%), and one product contained mainly Z esters. Also, we detected the presence of MZ in 6 out of 7 products tested, which did not declare the presence of this carotenoid on their label. In these products, MZ contributed between 0.7% to 11% of the total carotenoid content. The other 2 products did declare MZ on their label and contained over 100% of the declared amount (122% and 127%).
Conclusions: This experiment shows that commercially available food supplements (containing the macular carotenoids) typically contain more L than declared on the product label, whereas Z concentrations are lower in some products. Also, we identified the presence of MZ in products not declaring this carotenoid on the product label. These findings have important implications for scientific research and for clinical recommendations involving these nutrients.
Disclosures: Alfonso Prado-Cabrero is a Howard Fellow and his research program is supported by the Howard Foundation (English Charity reg. number 285822) via a commercial grant from Iosa (Industrial Orgánica SA, Monterrey, Nuevo León, Mexico), MacuHealth LLC™ (Birmingham, Michigan, USA) and MacuVision Europe Ltd (Solihull, UK); all of the above organizations have an interest in commercially available supplements containing the macular carotenoids.

(MC020)

LUTEIN, ZEAXANTHIN AND MESO-ZEAXANTHIN CONTENT OF EGGS LAID BY HENS SUPPLEMENTED WITH FREE AND ESTERIFIED XANTHOPHYLLS

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Purpose: The xanthophyll carotenoids lutein (L), zeaxanthin (Z), and meso-zeaxanthin (MZ) are found at the central part of the retina, where they are referred to as macular pigment (MP). MP is studied in humans because of its proven role in enhancing visual function and its putative role in protecting against age-related macular degeneration (AMD). These benefits are likely due to the antioxidant and short-wavelength filtering properties of MP. It is known that eggs are a dietary source of L and Z. This experiment was designed to measure the yolk carotenoid response to hen supplementation with L, Z, and MZ.
Methods: Forty hens were used in the trial and were divided into 8 groups of 5 hens. Each group was supplemented with (~140 mg active xanthophylls/Kg feed) of one of the following oil-based carotenoid formulations for 6 weeks: unesterified Z (Group 1); Z diacetate (Group 2); unesterified L (Group 3); L diacetate (Group 4); L:MZ (1:1) diacetate mixture (Group 5); L:MZ diacetate (1:3) mixture (Group 6); MZ diacetate (Group 7); unesterified MZ (Group 8). Yolk carotenoid content was analyzed weekly (in 4 randomly-selected eggs) by high-performance liquid chromatography (HPLC).
Results: We obtained a significantly positive ($p<0.001$) time effect in all cases, suggesting strongly that the carotenoid concentrations in all L-, Z-, and MZ-supplemented groups increased significantly over the duration of the study, albeit to varying extents. We found that hens supplemented with Z/MZ diacetate produced eggs with significantly greater carotenoid concentrations than their free form counterparts.
Conclusions: This finding potentially represents the development of a novel food, suitable to increase MP and its constituent carotenoids in serum.
Disclosures: This project was supported by the Howard Foundation. The other authors report no potential conflicts of interest.

(MC021)

THE ASSOCIATION BETWEEN POLYUNSATURATED FATTY ACID CONTAINING LIPIDS AND CAROTENOIDS IN ALZHEIMER DISEASE PATIENTS AND MATCHED CONTROLS

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Purpose: The global lipid profile of blood plasma or serum reflects energy homeostasis in response to diet and lifestyle within an individual, and can discriminate a number of cardio-metabolic diseases associated with increased energy intake, and subsequent changes in the lipid profile. Mapstone and colleagues recently reported that development of memory loss, such as that caused by Alzheimer disease (AD), is associated with distinct changes in the lipid profile of blood plasma.
Methods: We determine the lipid profile of 29 AD patients and 24 matched controls, using direct infusion high resolution mass spectrometry, providing information on 162 lipid signals.
Results: The lipids we found are similar to the differentiating lipids found in the previous study (PCaa [40:6], PCaa [38:6], PCae [38:4]), but changes in these lipids are not specific to the pathology of AD since those lipids which contain n3 and n6-polyunsaturated fatty acids can be easily influenced by diet. Our results suggest that lipids will provide poor biomarkers per se for AD, but instead reflect the effects of a potentially beneficial diet in the elderly. In addition it has been shown that AD patients have lower levels of plasma carotenoids like lutein and zeaxanthin. In this report we explore the association between specific poly unsaturated lipids and carotenoids between AD patients and matched controls.
Conclusions: n3-PUFAs and carotenoids are both used as markers of a healthy diet but it is not clear whether their inverse association with AD suggests the importance of a healthy diet at a later age or reveals insight into the mechanism of AD.
Disclosures: The authors declare no competing financial interests.

(MC022)

CNS XANTHOPHYLL STATUS AND NONSPECIFIC BRAIN ACTIVATION IN YOUNGER AND OLDER ADULTS

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Purpose: High levels of lutein (L), zeaxanthin (Z), and their isomers in retina and brain have been related to improved performance on a number of measures that are known to be mediated by the central nervous system (ranging from balance and visual motor function to executive function and cognitive ability). To date, however, the relation between L + Z status and brain function measured directly has not been assessed. In this study we measured L + Z status (quantified by macular pigment optical density, MPOD) and related it to brain activity measured by high-density electroencephalography (EEG).
Methods: A total of 79 participants ranging in age from 18-92 years completed dense array, vertex referenced EEG using a 256 sensor Geodesic Sensor Net and NetAmps 200 amplifiers. Stimuli evoking the signal consisted of a 1-deg, long-wave "red" target that oscillated at frequencies ranging from 5-33.3 Hz, on a 20-deg "red" circular background. MP optical density was measured psychophysically via heterochromatic flicker photometry.
Results: Significant differences were detected in nonspecific brain activity across age ($p<0.05$). Individuals with high MPOD (M = 0.69) had significantly higher ($p<0.05$) nonspecific brain activity than individuals with low MPOD (M = 0.25) across subjects of all ages.
Conclusions: Higher levels of L + Z in the CNS are related to measurable differences in brain activity (increased nonspecific brain activation).
Disclosures: This study was funded by Abbott Nutrition. Author Lisa Renzi is an employee of the University of Georgia. During a portion of data collection, Dr. Renzi was an employee of Abbott Nutrition. Author Billy Hammond has received speaking fees from Abbott Nutrition.

(MC023)

A NOVEL SMARTPHONE APPLICATION TO ENABLE SELF-MONITORING FOR INDIVIDUALS WHO ARE VULNERABLE TO DEGENERATIVE MACULAR CHANGES: THE MACULAR INTEGRITY APP (MIA)

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Purpose: It is well-recognized that when macular degeneration advances from the early stage, prompt investigation and intervention leads to better long term outcomes. Historically, the Amsler chart has been offered to vulnerable patients as a means of self-monitoring. The familiar Amsler chart has many immutable advantages; the square grid being probably the most sensitive target to flag metamorphosis. The test developed transposes the sensitivity of the Amsler grid to a modern format.
Methods: The MIA is displayed on a smartphone, and presents to the patient 2 parallel columns of squares. Within each column, a number of squares are misaligned, to unequal degrees in each column. By means of a refinement algorithm, the smallest discernible distortion is identified. This generates a distortion score along that meridian. This is repeated along a number of meridians, and a geographic distortion score generated.
Results: The MIA test has been refined over a period of ten years in optometric practice, and side by side comparisons made with the Amsler chart for patients with varying stages of AMD.

Conclusions: The test shows promise in identifying changes at an earlier stage than the Amsler chart, in addition to generating a distortion score which can be used to monitor progression and prompt further investigation. However, the test would benefit from more robust research to optimize the potential of this technology.

(MC024)
THE EFFECT OF ETHNICITY ON THE ASSOCIATION BETWEEN MACULAR PIGMENT DISTRIBUTION AND FOVEAL ANATOMY IN HEALTHY INDIVIDUALS
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Purpose: Macular pigment distribution may be associated with foveal anatomy. We explored the effect of ethnicity on this relationship.
Methods: Macular pigment optical density (MPOD) was measured using heterochromatic flicker photometry in 76 white, 80 South Asian, and 70 black volunteers aged 18 to 39. MPOD spatial profiles were classified as exponential, ring-like, or central dip. Foveal pit morphology measurements including inner retinal thickness (IRT) and foveal width (FW) were taken from Spectralis OCT scans. Mean spherical error and age was controlled for in analyses.
Results: MPOD profiles were associated with ethnicity ($p = 0.009$): 58% with ring profiles were South Asian and 43% with dip profiles were black. Integrated MPOD up to 1.8° (MPOD INT) was higher in ring (0.96 ± 0.26) and dip (1.00 ± 0.32) compared to exponential profiles (0.66 ± 0.21; $F[2] = 45.9$, $p<0.0005$). Although white subjects had thicker IRT at 0° (130 ± 21 µm) than South Asians (123 ± 16 µm) and blacks (116 ± 141 µm; $F[2] = 12.4$, $p<0.0005$), and FW was narrower in whites (2282 ± 225 µm) than South Asians (2474 ± 260 µm) and blacks (2449 ± 284 µm; $F[2] = 12.6$, $p<0.0005$), foveal anatomy showed no difference between profiles ($p>0.05$). MPOD INT was positively correlated to IRT at 0° only in blacks ($r = 0.35$, $p = 0.003$), but not related to FW in any ethnic group.
Conclusions: Ethnicity plays an important role in variations observed between MPOD profiles. While foveal morphology presented different characteristics across ethnic groups, this did not explain variations in MPOD distribution. Ethnicity is a covariate that should not be overlooked when investigating relationships between MPOD and foveal anatomy.

(MC025)
NEURAL ACTIVATION DURING VISUAL ATTENTION TASK DIFFERS IN ELDERS WITH HIGH VS LOW MACULAR PIGMENT DENSITY
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Purpose: High levels of macular carotenoids lutein (L), zeaxanthin (Z) and their isomers in the central nervous system (CNS) have been linked to improved visual processing speed and visual attention. These improvements in visual performance have never been tied directly to brain activation, nor have they been studied in a visually and cognitively demanding task scenario, in which visual attention must occur in the presence of noise. The purpose of this study was to directly compare CNS L + Z levels (quantified by macular pigment optical density, MPOD) with brain activity measured by dense array electroencephalography (EEG), using stimuli designed to stress visual attention resources.
Methods: A total of 88 participants ranging in age from 18-92 years of age were recruited. Participants were divided into 2 groups (18-30 and 65-90 years) by age. EEG data were collected using a 256 sensor Geodesic Sensor Net. Stimuli evoking the signal included a grating array of vertical bars presented at 1-deg. Bars oscillated at 4 different driving frequencies, and participants were instructed to covertly attend to width changes in a specific sub-set of bars. MPOD was measured psychophysically via heterochromatic flicker photometry.
Results: Significant differences were detected in the EEG signal at driving frequencies by age ($p<0.05$) and across nonspecific brain frequencies by age ($p<0.05$). Elders divided into high MPOD and low MPOD groups showed significant differences at attended driving frequencies ($p<0.02$) and at nonspecific frequencies surrounding the driving frequencies ($p<0.05$).
Conclusions: CNS xanthophyll status is related to differences in brain activation in conditions designed to stress visual attention ability in older adults.

Disclosures: This study was funded by Abbott Nutrition. Author Lisa Renzi is an employee of the University of Georgia. During a portion of data collection, Dr. Renzi was an employee of Abbott Nutrition. Author Billy Hammond has received speaking fees from Abbott Nutrition.

(MC026)
LUTEIN LEADS TO A DECREASE OF FACTOR D (FD) SECRETION BY *IN VITRO* CULTURED MATURE ADIPOCYTES
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Purpose: The complement system plays an important role in the pathogenesis of age-related macular degeneration (AMD). In a previous study, we found that the plasma levels of Factor D (FD) decreased significantly with daily lutein supplementation. FD, a rate-limiting enzyme of the alternative complement pathway, is also known as adipsin and it is mainly secreted by adipose cells. The purpose of this *in vitro* study was to determine whether lutein influences FD secretion by adipose cells.
Methods: The Simpson-Golabi-Behmel syndrome (SGBS) cell line was used to investigate the effect of lutein on FD production. Cells were incubated in a special medium containing dexamethasone, 3-Isobutyl-1-methylxanthine (IBMX) and rosiglitazone, which allows differentiation of the SGBS cells into mature adipocytes. The obtained mature adipocytes were subsequently stimulated with a dose of 50 µg/mL lutein. The supernatants of the SGBS cell cultures were collected at 24 and 48 hours and FD concentration was determined by ELISA. The mRNA expression of Factor D was detected by quantitative real-time PCR.
Results: We obtained a confluent monolayer of mature adipocytes containing a variable degree of fat globules after culture of SGBS in a special differentiation medium. The culture supernatant contained readily detectable levels of FD of 233.9 ± 17.9 ng/mL. After 48 hours exposing cells to lutein, a significant reduction of the secretion of FD in the supernatant of adipocytes was found as compared to vehicle controls. Meanwhile, exposed cells to lutein for 48 hours resulted in a significant down-regulating effect on the mRNA expression of FD in adipocytes.
Conclusions: Lutein modulates the production of FD in mature adipocytes. Both protein and mRNA activities were depressed, which may lead to a novel therapeutic approach to control the inflammatory pathway of the innate immune system in AMD.
Disclosures: All authors claimed that there is no conflict interest in this abstract.

(MC027)
THE GLOBAL MARKET FOR LUTEIN AND RELATED CAROTENOIDS: CURRENT STATUS AND FUTURE CHALLENGES
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Purpose: Carotenoids are organic pigments that play important roles in photosynthesis and photoprotection. They are synthesized in plants and some bacteria and fungi. The carotenoid lutein is well known as a filter of high energy blue light and as an antioxidant that provides protection from oxidative stress in plants and humans. Lutein, together with mesozeaxanthin and zeaxanthin, are found at the macula, a specialized part of the retina responsible for central vision, where they are collectively known as macular pigment (MP). MP has been shown to play a key role in supporting visual function in humans, and is believed to protect against the world's leading cause of blindness, a disease known as age-related macular degeneration. The aim of this study was to conduct an assessment of the current global market for lutein and related compounds, and an evaluation of future challenges.

Methods: We conducted primary and secondary research, which focused on key players in the global lutein market, from source to retail outlets. We conducted research into market analysis, current supplier base and competitive assessment. In particular, 13 interviews with suppliers in the carotenoid supply chain were conducted.
Results: The global carotenoid market is currently valued at $1.3 billion, and is growing at 2.3% pa. A consistent increase in the global carotenoid market value is evident since 2005, and is forecast until 2020, with β-carotene, astaxanthin, and lutein representing the biggest, second biggest and third biggest contributors, respectively. This study found that the largest regional carotenoid market is Europe, representing 37% of the world market, and is primarily driven by uses in animal feed and food industries. The lutein market for use in eye health is predicted to grow faster than any other application of lutein. In 2015, the eye-health lutein market is valued at circa $165 million, but is expected to reach $215 million by 2019. Of note, lutein does not compete with a respective synthetic compound as is the case with astaxanthin and β-carotene. Challenges for those involved in the carotenoid industry include regulatory issues, competition and availability of raw material. Further, the carotenoid industry is becoming increasingly consolidated, with key players becoming increasingly dominant. Novel competing technologies are also being explored, and in some cases, applied.
Conclusions: The carotenoid market, especially lutein, is growing, and will continue to do so.

(MC028)
ZINC DEFICIENCY IS COMMON EVEN IN YOUNG AND HEALTHY INDIVIDUALS
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Introduction: Zinc (Zn) is an essential element for appropriate functioning of the body at all stages of life, including cell synthesis, tissue repair and brain development. The immune system requires Zn for maintaining the structural integrity of DNA and the synthesis of nucleic acids and proteins. Zn is a cofactor of numerous enzymes (lactate dehydrogenase, alkaline phosphatase, carbonic anhydrase, carboxypeptidase) and is important for the functioning of several organs including the retina, where it is involved in the regeneration of rhodopsin and other essential visual functions.
Objective: To determine the Zn and nutritional status in a healthy population and establish relationships with other factors such as exercise, alcohol consumption and certain biochemical parameters.
Methods: The study was conducted in Granada, Spain, in a group of healthy people aged 21 to 59 years: 56 men and 61 women. Subjects included did not have any known pathology that could affect their nutritional status and were willing to participate in the study. Blood was taken and Zn was analyzed by Atomic Absorption Spectrometry (AAS) in plasma samples using wet mineralized technique. A standard food frequency questionnaire was used, and subsequently analyzed using the software Nutriben (Mataix, and Garcia Diz, 2006) obtaining the percentage of recommended daily allowance (RDA). The clinical parameters in blood were analyzed using colorimetric method on the Hitachi autoanalyzer. The study was approved by the Ethics Committee and informed consent was obtained.
Results: The RDA of Zn in the adult population is 7 to 15 mg/day. Our results show that Zn intake was below two-thirds of the RDA in 56% of the participants; while in the plasma Zn deficiency occurred in 17%. There was a significant positive correlation between Zn levels and alcohol consumption including liver function, inflammatory factors such as Immunogen, InmunoA, and alpha-1-antitrypsin (for all $p<0.05$). Negative correlation was found with exercise intensity, LDH and rheumatoid factor.
Conclusions: Our results show that even in a population perceived to be healthy, Zn deficiency is relatively common even in younger age groups. Zn is not routinely measured and so parameters associated with potential Zn deficiency are important to establish, in order to reduce the burden of diseases later in life, some of which might be age-related macular disease and diabetic retinopathy.

(MC029)
A COMPARISON OF VISUAL ACUITY AND CONTRAST SENSITIVITY MEASUREMENTS OBTAINED USING A COMPUTER GENERATED ALGORITHMIC TEST (MULTIQUITY®) AND A CONVENTIONAL COMPUTER DISPLAY SYSTEM (THOMPSON TEST CHART 2000 XPERT)
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Purpose: Early detection of sight loss allows for early intervention and better outcomes for the patient. Current visual acuity (VA) tests have coarse grading, and are not sensitive to measuring global visual function. We developed computer generated algorithmic acuity and contrast tests, which have a near-continuous decremental scale allowing for more sensitive assessments of visual function across patient populations.
Methods: The MultiQuity® tests present to the patient a display of 3 optotypes (contrast: 3 levels). The patient indicates the smallest letter or lowest level that can be identified, and the next triplet of optotypes is displayed. The range is stepwise reduced until the acuity (or contrast) threshold is reached. The conventional reference test was performed in known line by line procedure. Acuity and contrast was measured in one eye of 73 subjects (including 12 with age-related macular degeneration and 8 with cataract). Regression was used to convert MultiQuity® scores into the Thompson scale. Concordance between the devices was investigated using standard agreement indices. A further 24 subjects were tested on both devices to investigate test-retest variability.
Results: Agreement was strong between both devices for both acuity and contrast, as was test-retest agreement. For corrected distance VA (CDVA), agreement was strong between the devices (accuracy = 0.993, precision = 0.889, CCC = 0.883). For contrast sensitivity (CS), agreement was also strong (accuracy = 0.996, precision = 0.911, CCC = 0.907). Agreement was unaffected by demographic variables or by presence/absence of ocular pathology. Test-retest agreement indices for both devices were excellent: in the range 0.88-0.96 for CDVA and in the range 0.90-0.98 for CS.
Conclusions: In this study comparing visual function (i.e. CDVA and CS) measured on the Thompson test chart and MultiQuity®, measurements on the 2 devices were found to be concordant, and test-retest reliability was good for both devices. The near continuous grading of the MultiQuity®-system has the potential to identify changes in visual function earlier, as it produces results in over 700 steps for VA and 200 steps for CS, which far exceeds the number of steps in the Thomson test chart, and is therefore capable of detecting even minor changes in visual function.
Disclosures: Kuchling, O'Regan Nolan, Beatty: Directors of SightRisk Ltd. Dennison, Akuffo, Stack: none.

(MC030)
THE IMPACT OF SUPPLEMENTAL MACULAR CAROTENOIDS AND B VITAMINS IN SERUM OF PATIENTS WITH ALZHEIMER DISEASE
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Purpose: To investigate serum response to supplemental lutein (L), zeaxanthin (Z), meso-zeaxanthin (MZ), B vitamins, and folic acid in patients with Alzheimer disease (AD).
Methods: At the initiation of the study, 31 patients with AD and 31 age-similar controls were recruited and randomly assigned to placebo (sunflower oil) or active intervention containing 10 mg L, 10 mg MZ, and 2 mg Z (Macushield™) (1). At 6 months, subjects on the active intervention arm were provided with an additional intervention containing 20 mg vitamin B6, 500 mcg vitamin B12, and 800 mcg folic acid (Trio Be Plus). Compliance to the study interventions was monitored strictly in this trial by nurse visits and career reports. Blood samples were analyzed at baseline, 6 months, 12 months, and 18 months.

Serum concentrations of L, Z, and MZ were quantified in-house by HPLC, and serum homocysteine (HCY) and folate concentrations were assessed using the ARCHITECT®i System by Biomnis Laboratories (Sandyford, Dublin, Ireland). MP was measured using dual-wavelength autofluorescence (Heidelberg Spectralis). The number of subjects remaining for this report (at 18 months) was 22 in the control group and 12 in the AD group.
Results: For all variables reported here, the placebo arms did not exhibit any significant change with time ($p>0.05$, for all). Serum L, Z, and MZ increased significantly with time in the active arm of the control subjects ($p<0.001$, $p<0.001$, and $p = 0.002$, respectively), whereas, in the AD group, serum L, Z, and MZ increased significantly in the active arm from baseline to 12 months ($p<0.001$, for all), and then exhibited an unexpected decline from 12 to 18 months, for L, Z, and MZ ($p = 0.10$, $p = 0.005$, and $p = 0.092$, respectively). MP increased significantly with time in the active arm of the control and AD subjects ($p<0.05$). Serum HCY decreased significantly in the active arms ($p = 0.003$), whereas serum folate and serum B12 increased significantly in the active arms ($p = 0.08$ and $p = 0.032$, respectively).
Conclusions: The most novel finding from this 18-month report is that in the active AD group, serum L, Z, and MZ significantly increased initially (comparable to the control group), and then exhibited an unexpected drop from 12 to 18 months. This may be explained, at least in part, by malfunction of the carotenoid transport/capture system in these patients in association with their AD progression. However, further study is needed to fully understand these findings.
Disclosures: Stephen Beatty and John Nolan are Directors of Nutrasight Consultancy Ltd., where they do consultancy work for companies with an interest in supplements for eye care. The other authors report no potential conflict of interest. This work was supported by Howard Foundation, Cambridge, UK.

(MC031)
COMPARISON BETWEEN MACULAR PIGMENT MEASUREMENT USING CUSTOMIZED HETEROCHROMATIC FLICKER PHOTOMETRY AND DUAL-WAVE AUTOFLUORESCENCE IN EARLY AGE-RELATED MACULAR DEGENERATION

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Purpose: To compare macular pigment (MP) measurements using customized heterochromatic flicker photometry (cHFP; Macular Metrics Densitometer™) and dual-wave fundus autofluorescence (Heidelberg Spectralis® HRA + OCT MultiColor) in subjects with early age-related macular degeneration (AMD).
Methods: A total of 117 subjects with early AMD were enrolled as part of the Central Retinal Enrichment Trial (CREST; ISCTRN13894787). Data analyzed here included baseline and 6-month study visits. MP for each subject was measured by cHFP using the Densitometer and by dual-wave fundus autofluorescence using the Spectralis. Agreement was investigated at 4 different retinal eccentricities, both graphically and using agreement indices including Pearson correlation coefficient (precision), accuracy coefficient, and concordance correlation coefficient (CCC).
Results: Agreement was poor between the Densitometer and Spectralis at all eccentricities, both at baseline (e.g., at 0.25° eccentricity: accuracy = 0.63, precision = 0.35, CCC = 0.22) and at 6 months (e.g., at 0.25° eccentricity: accuracy = 0.52, precision = 0.43, CCC = 0.22). Agreement was unaffected by age, cataract, or AMD grades, but disagreement between the 2 devices was significantly greater for men at 0.5° ($p = 0.025$) and 1.0° ($p = 0.007$) of eccentricity.
Conclusions: In subjects with early AMD, MP measurements using the Densitometer and Spectralis are not comparable and should not be used interchangeably in the clinical and/or research setting.

(MC032)
THE ROLE OF MICRONUTRIENTS IN THE TREATMENT OF VITREOUS FLOATERS

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Purpose: AREDS and other studies with macular carotenoids have proven that chronic eye diseases can be modulated with micronutrients. Vitreous floaters can have a considerable impact on the visual perception and quality of life. So far there is no standard therapy for vitreous floaters, although vitrectomy is indicated in severe cases. As floaters may be a result of a disturbed connective tissue metabolism, interventions with food supplementation comprising of water-soluble antioxidants, modulators of the glycation of collagens, and inhibitors of collagenase, elastase and hyaluronidase were carried out. The potential role of macular carotenoids will be discussed.
Methods: Two clinical supplementation trials have been performed in patients presenting with symptomatic vitreous floaters. A food supplement containing 125 mg of L-lysine, 40 mg of vitamin C, 25 mg of *Vitis vinifera* extract (procyanidines), and 60 mg of *Citrus aurantinium* flavonoids per capsule (VitroCap®) was tested. Study 1: noncontrolled study in 24 patients; treatment: 1 capsule per day, orally for 3 months. Symptoms were measured utilizing a 5 point assessment scale. Study 2: prospective, monocentric, controlled study in 62 patients between 40 and 63 years, presenting with bilateral floaters; 29 patients randomised to treatment: 1 capsule per day, orally for 3 months, 33 patients randomised to control: watchful waiting.
Results: The mean age of the patients in study 1 was 62 years. The symptom score of the subjects improved from 3.63 to 1.3. A total of 87.5% of the subjects (n = 21) responded to the treatment after 3 months. The response rates were similar considering the dimensions of the score "complaints during reading" (80%) and "complaints during car driving" (86%). In study 2, the mean age of the patients was 57 years in the treatment group (25/75 percentile: 42/62 years) and 54 years in the control group (25/75 percentile: 40/64 years). In the supplemented group, 65.5% of the patients showed improvement compared to 12.2% in the control group ($p<0.05$). No adverse event was reported in any patient group.
Conclusions: Supplementation of vitreous floaters subjects shows a clinically relevant improvement of the condition. Furthermore, in a controlled study a significant advantage has been shown over the control group under "watchful waiting." This approach establishes an additional effective and safe option for treating vitreous floaters.
Disclosures: Roland Brinckmann: ebiga VISION GmbH; others: none.

(MC033)
PERCEIVING POLARIZATION WITH THE NAKED EYE: CHARACTERIZATION OF HUMAN POLARIZATION SENSITIVITY

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Purpose: Humans can detect the polarization of light using an entoptic effect known as Haidinger's brushes, which is thought to be mediated by dichroic carotenoids present in the macula. We sought to measure the lower threshold of detection of Haidinger's brushes with respect to the percent polarization of the light field.
Methods: We presented flashing horizontal and vertical gratings on a modified liquid crystal display screen, which produces images in polarization contrast instead of color or intensity. Using custom-made diffusing filters, the polarization of light was changed in ascending and descending steps over the range 0%-100%. Participants reported the orientation of gratings presented at each step.
Results: Participants were, on average, able to perform the task down to a threshold of 56%, with some able to go as low as 23%.
Conclusions: Humans are sensitive to the polarization of light at lower percent polarization values than other vertebrates reported to possess polarization vision. The observed variance in percent polarization threshold may

be linked to variation in macular pigment optical density (MPOD), which is known to vary among individuals, and which supports previous links between MPOD and the dichroic ratio of the macula. In future, we will investigate the potential correlation between MPOD, measured using heterochromatic flicker photometry (HFP), and our percent polarization threshold for detection of Haidinger's brushes by making measurements in the same individuals.

SPEAKERS ABSTRACTS

THE COMPLEXITY OF SPATIAL PROFILES OF MACULAR PIGMENT

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It has been shown that peak macular pigment optical density (MPOD) is a poor predictor of the total amount of macular pigment present and it is more important to consider the overall distribution instead of a single central measurement of MPOD. There is general consensus that macular pigment peaks at the center of the fovea and sharply declines exponentially with eccentricity. There have been reports of variations from this typical profile, whereby an annulus of higher MPOD is superimposed on the exponential distribution, giving rise to a ring-like structure between 0.5 and 1.2 degrees eccentricity. These ring-like structures are also known as secondary peak, bimodal or atypical profiles of the macular pigment. There have also been reports of a central dip or plateau whereby a central peak is absent. However, variation in measurement techniques makes comparison between studies difficult.

In order to achieve a systematic study framework, we propose a universal objective classification system to compare MPOD profiles between studies, which can then be applied to any MPOD measurement technique. We report excellent agreement between visits of this objective classification method using HFP techniques ($k = 0.88$, $p<0.0005$) as well as FAF imaging ($k = 0.85$; $p<0.0005$) compared to visual classification ($k = 0.44$, $p = 0.02$).

The presence of a secondary peak has been found 3 times less common in eyes with presence of AMD compared to healthy eyes. In addition, nonexponential profiles of MPOD may be present more frequently in some ethnicities. This may contribute to ethnic variations seen in AMD prevalence, with lower prevalence of early AMD reported in individuals of black or Asian Indian compared to white ethnicity. Although these results suggest that nonexponential MPOD spatial profiles may play a role in the protection of the eye against AMD, no relationships have been found between MPOD profile type and the established risk factors for AMD such as age, smoking, and family history.

Using our objective classification system, we explored the effect of ethnicity on the macular pigment profile as well as the association with foveal anatomy measured with optical coherence tomography. Our data showed that ethnicity plays an important part in variations observed between spatial profiles while foveal architecture does not. While accounting for ethnic variations in retinal anatomy, foveal architecture provided no predictive values for the MP spatial profile.

LUTEIN AND INFLAMMATION

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It has been shown that, besides absorbing blue light and quenching free oxygen radicals, lutein also has anti-inflammatory properties. This may have implications in Age related Macular Degeneration (AMD), because an inflammatory mechanism involving the alternative complement pathway has been implicated in the pathogenesis of this disease. In addition, various complement activation products were increased in the circulation of AMD patients, providing evidence for a systemic inflammatory component to the disease pathogenesis. It may well be lutein administration affects the inflammatory component of AMD. First clues came from studies showing that administering lutein had a beneficial effect in an experimental model of AMD. Recently, we have reported that daily supplementation with lutein over a time period of 12 months led to a significant decrease in the plasma levels of the complement factors Factor D (FD), C3d, C5a, and sC5b-9. However, the mechanism of this finding is not clear.

The activation of the alternative complement pathway involves a number of cleavage reactions and amplification steps whereby complement components interact with each other in a strictly regulated manner. FD is a rate limiting enzyme in the activation sequence of the alternative pathway and as such a key player in this complement homeostasis. FD is also known as adipsin, since its main source is adipose tissues, where it is secreted by mature adipocytes. Since adipose tissue is also a main storage site for carotenoids such as lutein and zeaxanthin, we setup a study to investigate whether lutein influences FD secretion by adipose cells as a possible mechanism for the results above. Data, showing that lutein suppresses FD expression by mature adipose cells, both at the protein and the mRNA level, will be discussed.

CAROTENOID-CONTAINING FOODS TO IMPROVE HEALTH

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Purpose: Animals obtain carotenoids from the diet. Carotenoid levels in humans are frequently associated with a lower risk of developing some diseases, but is it reasonable to expect health benefits from them? Apart from reflecting on this question, this work is aimed at discussing diverse aspects about the carotenoid content of foods and their bioavailability.
Methods: Revision of previous bibliography.
Results: Overall, the presence of carotenoids in animals is thought to be beneficial. Animal colors mediated by them are usually honest signals that convey information about their physiologic and nutritional states and are important for their reproductive success. It is also frequent to find high levels of carotenoids in ovaries and eggs, suggesting that they may have a role in reproduction and development. Is it reasonable to expect health benefits mediated by carotenoids in humans? Some are consistently found in plasma and tissues, in milk (with higher concentrations in colostrum) and in infants. These and other facts suggest that they could be involved in beneficial roles at different. Therefore, it is sensible to investigate how to assure adequate intakes of these compounds. There are several databases and studies in which their levels in a wide variety of foods are reported, which are very valuable for epidemiologic studies. However, there is room for improvements. For instance, the carotenoid levels in a given food can vary markedly as a function of several factors (e.g., genotype, cultivation and processing conditions, among others), so this information should be somehow considered in future works. It is also becoming increasingly important to include in them data about their release from the food matrices, as this is a key process for their absorption.
Conclusions: Part of the future work in carotenoids should focus on determining intakes associated to health benefits. In this sense, it would be desirable to revise critically the compositional data already generated and to foster the inclusion of other information (e.g., effect of different factors in their levels, release from different food matrices) in future works.
Disclosures: There are not commercial relationships relevant to the content of the abstract.

MECHANISMS OF PRODUCTION OF MESO-ZEAXANTHIN

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Purpose: Meso-zeaxanthin (MZ) is a xanthophyll carotenoid that is rarely found in nature outside of the vertebrate eye. It is not synthesized by plants or micro-organisms, and it is not a constituent of the normal human diet, yet it comprises one-third of the primate macular pigment. Meso-zeaxanthin can be readily synthesized on an industrial scale from lutein, and my laboratory and others have provided evidence that lutein is the dietary precursor for MZ in primates and birds, but the biochemical mechanisms underlying this conversion remain a mystery.
Methods: It is known that domestic chicken eggs do not contain MZ, yet newly hatched chicks have MZ in their retinas. We analyzed a variety of chick embryo tissues at different developmental stages by chiral HPLC.
Results: We have been able to establish the tissue and developmental stage when MZ is first produced during chick embryo development.
Conclusions: Identification of the tissue when MZ is first formed in the chick embryo will facilitate identification of the enzymatic mechanisms underlying MZ formation in living animals.
Grant support: NIH EY-11600.
Disclosures: None.

OVERVIEW OF ALZHEIMER DISEASE AND ITS TREATMENT STRATEGIES

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Alzheimer disease (AD) is the most common neurodegenerative disorder. It is characterized by progressive symptoms of cognitive and functional decline and onset of behavioral and psychological symptoms. Its pathology is characterized by synaptic loss and the deposition of amyloid beta peptide plaques and tau protein in the form of neurofibrillary tangles. These occur as a result of a number of interactive processes that include oxidative stress, abnormal protein processing, inflammation, and mitochondrial dysfunction.
There is a strong association between dementia and older age with the likelihood of developing dementia doubling every 5 years after age 65. The prospective ageing of the population will lead to an exponential increase in the number of people with dementia in the years ahead. This will bring many challenges, not just for the person with dementia and the people caring for them but will also have considerable economic, health care and societal impacts.
The 2 classes of drugs currently licensed for therapeutic use in AD focus on neuro chemical modulation and are cholinesterase inhibitors and *N*-methyl-D-aspartate receptors antagonists. These target acetylcholine and glutamine respectively. While they have offered some symptomatic relief they do not halt the degenerative process. Despite extensive ongoing research, there have been no new drugs licensed for the treatment of AD since 2004. While we currently have no cure for dementia much of current research is investigating ways to decrease the risk of getting dementia or delaying its age of onset. Delaying the onset of AD by 2 years could reduce prevalence rates of AD by 20% and a delay of onset by 5 years could halve prevalence rates. The purpose of this talk is to give an overview of AD and to consider changes in approach to its prevention and management highlighting modifiable risk factors, nutritional deficiencies and possible interventions earlier in the disease trajectory.

ASSESSING COGNITIVE FUNCTION IN AD AND NON-AD PATIENTS

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The purpose of this talk is to provide an introduction to psychometric and methodological factors that are essential to consider when assessing cognition. Questions of "who," "why," and "how" are crucial; e.g., a test that is ideal for the detection of subtle cognitive impairment may be entirely unsuitable to measure change over time, or one that is too simple for one group may be too demanding for another. Cognition is typically viewed as comprising various constituent domains but there is no clear consensus on what defines these domains, how best to assess them, or exactly what various cognitive tests are measuring, e.g., fluency for "animals" has been varyingly reported as a primary measure of language, semantic memory, or executive functioning. Test performance is also affected by a wide range of noncognitive factors including age, education, premorbid intellect, severity of cognitive impairment, emotional, physical and motivational factors, the test environment and intrinsic measurement error and variability. This talk will focus on the assessment of cognition in Alzheimer disease (AD) and non-AD patients with particular reference to current models of memory functioning derived from neuropsychology, information processing and cognitive psychology that can guide test selection and interpretation. For illustrative purposes it will also draw on findings from recent studies by the Macular Pigment Research Group, Waterford Institute of Technology in groups with low macular pigment, age-related macular degeneration, or AD.

EXPLORING THE ROLES OF THE XANTHOPHYLLS IN MACULAR DEVELOPMENT

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Purpose: Evidence for the importance of the xanthophylls lutein and zeaxanthin (L/Z) in macular health has accumulated over the last 35 years, but little is known about their roles in macular development. The fovea, the central 1 mm^2 of the macula that underlies high acuity vision, has the body's highest lutein/zeaxanthin (L/Z) content and is the last retinal area to develop, leading to speculation that L/Z accumulation may influence foveal development by several possible mechanisms. Current methods for *in vivo* retinal imaging make possible detailed longitudinal assessment of multiple aspects of foveal development and effects of nutritional factors. Because only nonhuman primates have a macula and fovea like those in humans, they are the model of choice for such studies.
Methods: We adapted for use in infant monkeys multiple modes of *in vivo* retinal imaging, including color retinal fundus photography, ocular coherence tomography (OCT), fundus autofluorescence and adaptive optics imaging. The latter new technique allows acquisition of images of sufficiently high resolution to detect and quantify the density of cone photoreceptors. We are implementing these methods to compare rhesus macaque infants fed infant formulas with or without supplemental L/Z from birth until 6 months of age.
Results: Color fundus photographs demonstrated the rapid development of melanin pigmentation in the retinal pigment epithelium over the first 8 postnatal weeks. OCT images were analyzed to derive measures of foveal width, depth and volume and the thickness of retinal layers. Two key indices of foveal development—the length of cone outer segments and cone packing density—are being measured by OCT and adaptive optics imaging, respectively, and preliminary results will be described.
Conclusions: The developing retina can be imaged at high resolution with multiple techniques, and the resulting structural measures can be correlated with measures of macular function and vision. This study will provide a definitive evaluation of the effects of infant formula L/Z content on foveal development.
Disclosures: Supported by a grant from the Center for Nutrition, Learning and Memory at the University of Illinois at Urbana-Champaign, Abbott Nutrition and NIH grant P51-OD011092.

STRUCTURAL, FUNCTIONAL, AND MACULAR PIGMENT RESPONSE TO CAROTENOID SUPPLEMENTATION IN GLAUCOMA SUBJECTS

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Purpose: This study was designed to investigate the relationship between MPOD and glaucoma-relevant structural and functional measures at baseline and in response to carotenoid supplementation among glaucoma subjects.
Methods: Eighty-eight subjects with glaucoma were recruited into the Macular Pigment and Glaucoma Trial (ISRCTN: 56985060), a placebo-controlled, double-masked and randomised clinical trial. Subjects were assigned with equal probability to placebo (n = 44) or treatment arms (n = 44), which comprised an oral supplement containing 10 mg lutein, 2 mg zeaxanthin, and 10 mg meso-zeaxanthin for a period of 6 months. MPOD at 0.25°, 0.50°, and 1° of retinal eccentricity was measured using customized heterochromatic flicker photometry. Structural topography was assessed using optical coherence tomography, including the ganglion cell complex (GCC), which was used to stratify subjects into those with foveal-involved glaucoma versus those without. Visual function was assessed using a range of psychophysical tests including visual acuity, contrast sensitivity with and without glare, photostress recovery, 24-2 and 10-2 Humphrey perimetry.
Results: Fifty-two subjects were classed as foveal-involved according to the presence of GCC losses encroaching on the fovea. At baseline, glaucoma subjects with GCC loss involving the foveal zone had lower MPOD relative to those without foveal GCC involvement ($p<0.01$, for all eccentricities), and also had greater glaucoma severity. MPOD in this glaucomatous cohort was statistically significantly correlated with a broad range of structural (inferior peripapillary RNFL thickness, inferior GCC thickness, foveal inner retinal thickness, cup-disc area ratio, and optic disc rim area; $p<0.05$ for all) and functional measures (10-2 and 24-2 mean deviation and low spatial frequency contrast sensitivity under glare; $p<0.05$ for all). Following supplementation, central MPOD increased significantly in the treatment arm at 0.25° ($p = 0.01$) and at 0.50° ($p<0.01$) of retinal eccentricity, but not in the placebo arm ($p>0.05$ for all eccentricities). The response was significant in those with and without foveal

involvement. The magnitude of MPOD response, however, was small, and not associated with any structural or functional improvements.
Conclusions: This study compliments previous findings that glaucoma is associated with lower MPOD levels, and extends the relationship such that MPOD, it appears, is lower in more severe cases of glaucoma exhibiting foveal involvement. MPOD can be increased in glaucoma patients with oral MP supplementation, but the MPOD response was low relative to other studies. The association between MPOD and structural and functional aspects of glaucoma is intriguing, and points to a potential role of MP replacement therapy in glaucoma, albeit that this study serves to highlight the need for further study.
Disclosures: This study was supported by the Howard Foundation and Macuvision Europe.

PHENOTYPIC AND GENOTYPIC PREDICTORS OF MACULAR PIGMENT OPTICAL DENSITY (MPOD) LEVELS AND RESPONSE TO DIETARY LUTEIN AND ZEAXANTHIN IN THE CAROTENOIDS IN AGE-RELATED EYE DISEASE STUDY (CAREDS)

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Purpose: Previously identified statistically independent determinants of MPOD at 0.5 degrees and of MP response to the dietary and supplemental intake of lutein (L) and zeaxanthins (Z) may not account for joint factors which have a biological role. We employed partial least squares (PLS) regression to better screen for predictors of MPOD level and PLS discriminant analysis for predictors of MPOD response, allowing correlated predictors, using data from CAREDS.
Methods: 28 phenotypes and 439 tag SNPs were evaluated. 297 women were classified as low MPOD responders if reporting LZ intake >1.7 mg/day but had MPOD ranking ≥2 quintiles below their quintile for LZ intake. 400 women were adequate responders with MPOD equaled or exceeded their quintile ranking for LZ intake. Backward multivariate regression model selections were used to further prune predictors that were indicated by PLS models, and to compute algorithms to predict MPOD level and response.
Results: PLS analyses indicated novel genotypes predicting both low MPOD level and response including variants in genes thought to be related to carotenoid absorption (NPC1L1, ABCG8), cell membrane transport (SCARB2), long chain ω-3 fatty acids metabolism (FADS2, ELOVL 4 and 5) and retinal capture (STARD3) and several lifestyle and health phenotypes related to high risk for metabolic syndrome. The regression model for MPOD response including 53 variables had an area under the curve receiver operating statistic of 81%.
Conclusions: We present prediction models of MPOD levels and response which need further testing and validation in other samples. These may permit estimation of MPOD level in epidemiological studies and of low response to LZ intake in supplementation trials.
Disclosures: None

CHALLENGES IN EVALUATING THE ROLE OF XANTHOPHYLLS IN COGNITION ACROSS MULTIPLE LEVELS OF ANALYSIS

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Purpose: A number of different methods have been used to identify the relationship between xanthophyll levels and neurological and cognitive function. Each of these methods has different caveats, assumptions and challenges that should guide selection of a given method for a given function or outcome. The purpose of this presentation is to review these methods and their caveats, and to distinguish methods designed to stage disease from methods used to measure behaviors associated with healthy cognition.
Methods: The relevant literature will be reviewed, and novel data from an ongoing clinical trial of xanthophyll status, cognitive function, and brain health and function that uses a variety of cognitive tests, disease staging tools and direct measures of brain activity will be presented.
Results: Some "category confusion" currently exists in the literature. For example, measures designed to stage dysfunction have been used as measures of cognitive function in healthy adults, as have measures designed to pre-screen adult populations for potential dysfunction. Behaviors associated with adaptive cognitive strategies have not been distinguished from the strategies themselves, and neither has elucidated the underlying neurological mechanisms.
Conclusions: Selecting cognitive tests appropriate to the population of interest and understanding the assumptions and caveats of these tests enables better interpretation of cognitive outcomes. In order to understand how the macular xanthophylls influence cognition, relating changes in xanthophyll status with changes in brain activation and physiology is necessary.
Disclosures: Novel data presented are from a clinical trial supported by Abbott Nutrition. Lisa Renzi is an employee of the University of Georgia. During a portion of the data collection, Lisa Renzi was an employee of Abbott Nutrition.

GLOBAL PREVALENCE OF AGE-RELATED MACULAR DEGENERATION

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Purpose: This paper examines current level of knowledge on the prevalence and impact of age-related macular degeneration (AMD).
Methods: Review of current and relevant literature on the prevalence, incidence, and global impact of AMD.
Results: There is currently a transitional period in most regions around the world where mortality rates are falling but morbidity rates due to chronic diseases causing disability are on the rise. AMD is one of these diseases, and although it causes a relatively small percentage of worldwide blindness (7% versus 50% caused by cataract and uncorrected refractive error), its impact on society is substantial. Although the genetic background of the disease is becoming well understood, individual risk profile and progression to visual loss and blindness is still poorly mapped hence health-care provision is struggling to find the best way to deal with the increasing number of patient appropriately. Traditionally population based epidemiologic studies provided estimates of prevalence and incidence of early stages of the disease usually characterized by drusen, and also on late stages such as neovascular AMD and geographic atrophy among various racial/ethnic groups around the world. These studies were mainly based on color fundus photography and these might not represent the disease spectrum accurately, therefore new, preferably multi-modal imaging will need to be employed to further understand differences between populations. It is well established, that AMD is universally present in all racial groups, however, studies report more prevalent disease in Europeans than in Asians or of those of African origin. Even between the European cohorts, the frequency of neovascular and atrophic disease varies significantly, and these differences themselves generate questions on causative effects and genetic –environmental interaction of the disease. Current treatment options place further burden on health budgets and patients and their carers alike without clear long-term prognosis for maintaining vision.
Conclusions: AMD has become better characterized and understood in the past decades but there are still significant questions on how to treat the individual patient best, especially those with high risk characteristics for progression to late AMD. Clear population policies on long-term prevention are lacking and might need to be considered in light of the current trend of longevity.
Disclosures: None.

DISTRIBUTION OF LUTEIN IN MEMBRANES OF RHESUS MACAQUE BRAIN: RELATIONSHIPS TO CELL FUNCTION AND VIABILITY

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Purpose: Lutein selectively accumulates in primate brain and may benefit cognition. Lutein's subcellular membrane distribution is unknown. Determining lutein's precise location in brain may elucidate its function.
Methods: Brain membranes of rhesus macaque (n = 11) were isolated using differential centrifugation. Carotenoids and fatty acids were extracted using standard lipid methods and were measured by HPLC and GC, respectively. Carotenoid data are expressed per mol% stearic acid. Cell viability markers include cell survival signaling, gene regulation, and oxidative stress and will be measured by Western Blots, RNA sequencing, and 8-oxo-2-deoxyguanosine, respectively. F4-neuroprostanes (oxidized DHA) will be measured by LC-GC/MS.

Results: To date, carotenoid data in frontal cortex, hippocampus and striatum (n = 3) are available. Lutein was the only carotenoid detected in all brain sections and membranes, despite detection of other carotenoids in whole brain. Lutein was differentially distributed among membranes with differences depending on the brain section. For example, in hippocampus, myelin membrane had significantly higher levels than that of mitochondrial membrane. Data from remaining monkeys will be available in June 2015.
Conclusions: Results from this study will provide a critical step in understanding lutein's role in brain function.
Support: Center for Nutrition, Learning and Memory at U. Illinois Urbana-Champaign, Abbott Nutrition, USDA 58-1950-0-014.
Disclosures: M.J. Kuchan is an employee of Abbott Nutrition.

A FEAST FOR THE EYE

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Carotenoids are associated with good health and reduced risk of serious degenerative diseases and disorders. In particular, some individual carotenoids, namely beta-carotene, lutein, and zeaxanthin, are associated with eye health. The required carotenoids must be provided from the diet, in food or as supplements. An overview will be presented of the occurrence of various carotenoids in food, considering especially what foods may be good sources of those carotenoids that are important for eye health. The main emphasis will be on the macular xanthophylls lutein and zeaxanthin, both in the present day diet and as the human diet and food availability have changed over the years. Important factors such as the food structure and the state of the carotenoids within it, and the uptake and transport of the carotenoids in the body will also be considered, because these can strongly influence the efficiency with which the carotenoids can be obtained from the food and used by the body.

OXIDATIVE STRESS, CAROTENOIDS, AND DEMENTIA

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Purpose: To investigate oxidative stress in patients with Alzheimer disease (AD) with and without vascular disease compared with controls.
Methods: We used spectrophotometry, ELISA and HPLC to measure plasma lipids, water-soluble (vitamin C and uric acid) and lipophilic (vitamin E, vitamin A, carotenoids including lutein, zeaxanthin, beta-cryptoxanthin, lycopene, alpha- and beta-carotene) antioxidant micronutrients as well as levels of biomarkers of lipid peroxidation, protein oxidation and protein nitration in patients and controls.
Results: Lower concentrations of cholesterol-carrying high density lipoprotein (HDL) and its principal apolipoprotein A1 (ApoA1) were observed in AD with vascular complications. HDL transports oxocarotenoids which are scavengers of peroxynitrite. All antioxidants with the exception of beta-carotene, were lower in demented patients as compared to controls. Lutein, lycopene, and zeaxanthin concentrations were significantly lower in AD patients with a vascular component and oxocarotenoid concentrations correlated with Mini-Mental State Examination scores. AD and vascular AD patients showed significantly protein oxidation as compared to controls.
Conclusions: We conclude that, independent of its nature—vascular or degenerative—dementia is associated with the depletion of a large spectrum of antioxidant micronutrients and with increased protein oxidative modification.

PLASMA LEVELS IN BREAST-FED INFANTS AS A GUIDE FOR THE ADDITION OF LUTEIN AND ZEAXANTHIN TO INFANT FORMULA

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Purpose: Identification of the appropriate concentration of lutein (L) and zeaxanthin (Z) for addition to infant formula (IF) is escalating in importance as research increasingly implicates possible roles for L/Z in brain development and function. While IF manufacturers generally emulate the composition of breast milk (BM), concentrations of L and Z in BM are highly variable. Average concentrations can vary by 3-fold amongst geographic locations and cultures. Further, BM L/Z are approximately 4 times more bioavailable than those added to IF when assessed by infant plasma concentrations. Also, dose response studies in formula-fed infants have revealed nonlinear dose responses in infant plasma and have led to plasma levels which exceeded those observed in US breastfed infants. While previous studies demonstrated high L/Z concentrations in BM from coastal China, the resulting concentrations in infant plasma were not measured.
Methods: Breastfeeding mother-infant dyads were recruited in Shanghai, China. Mothers reported daily consumption of more than 100 g of green leafy vegetables. Maternal plasma (9 wk postpartum), 2 breastmilk (9, 12 wk), and infant serum (12 wk) samples were collected using standard methodology. Three-day dietary records were collected for maternal diet.
Result: BM L/Z levels averaged 6.5 µg L/dL and 1.5 µg Z/dL and were about 3X higher than those reported for US BM. Concentration positively correlated with maternal L/Z intake ($r^2 = 0.43$, $p<0.0001$). Mean infant plasma levels (16.1 µg L/dL and 3 µg Z/dL) were also higher than US values and positively correlated with BM L and Z ($r^2 = 0.35$, $p<0.0012$).
Conclusions: The findings reveal that infant plasma L and Z continue to increase in response to high levels in BM from women consuming recommended amounts of vegetables and fruits. In combination with traditional IF safety criteria, these plasma values should define safe target addition levels of L/Z to IF. A remaining frontier is to understand the higher bioavailability of breast milk L/Z and any related differences in delivery to brain and eye. These questions are increasing in importance as research is rapidly accelerating our understanding of the roles of L/Z in brain and eye function.
Disclosures: M.J. Kuchan, X. Zhao, and Y.L. Low are employed by Abbott Nutrition.

MACULAR CAROTENOIDS AND BREAST MILK

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Purpose: To investigate further the transport of the xanthophylls, lutein and zeaxanthin, into human milk from the maternal circulation, to review the current status of the literature and integrate our understanding of the transport process.
Methods: Milk and blood samples were obtained from 75 Peruvian women and lutein and zeaxanthin levels were analyzed by HPLC. Carotenoid levels were assessed in comparison to the growing body of literature that describes the status of lutein and zeaxanthin in human.
Results: In the past 25 years approximately 30 papers have appeared in which lutein and zeaxanthin levels are described in human milk. The combined L + Z concentration was reported by many but more recent papers provide measurements of the levels of L and Z individually in milk. Our current data are consistent with previous studies demonstrating levels of lutein and zeaxanthin levels in milk vary widely between individuals (4.14-0.15 nmol/g fat). Individual lutein measurements correlate well between serum and milk. We observed ratios of lutein to zeaxanthin which averaged near 2.5 in both serum and milk samples, consistent with elevated levels of zeaxanthin in the diet of these women.
Conclusions: The amounts of the polar xanthophylls present in milk samples, although lower than those in serum, are surprisingly high compared to the nonpolar carotenes and are consistent with active transport of xanthophyll rich HDL into maternal milk. Preferential transport of xanthophylls into milk correlates with the rapid increases in macular xanthophylls that occur in the developing infant retina during the period most infants are exclusively breast fed.

CLINICAL EXPERIENCE WITH CAROTENOIDS NUTRIENTS IN EXUDATIVE AGE-RELATED MACULAR DEGENERATION

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Exudative macular degeneration is caused by upregulation of vascular endothelial growth factor (VEGF). Reactive oxygen species is a well-known upregulator of VEGF transcription and protein production. The purpose of this study was to see if supplementation with meso-zeaxanthin, lutein, and zeaxanthin the main constituents of macular pigment could prolong the need for anti-VEGF injections in patients who have developed exudative age related macular degeneration. During this presentation we will go over several cases

where Macuhealth was used in lieu of anti-VEGF therapy and was able to preserve vision, reduce subretinal fluid and obviated the need for intravitreal injections.

MACULAR CAROTENOIDS AND THEIR MEASUREMENT: SOME OPEN QUESTIONS

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Purpose: In this presentation, several issues will be raised: 1) Is the description of meso-zeaxanthin (MZ) as the "central carotenoid" justified? 2) Does HFP provide us with MPOD at the edge of the stimulus? 3) Is a basic assumption of HFP, that spectral sensitivity is the same in the fovea and parafovea, correct? 4) Can an apparent age-related decline in MPOD be an instrument-based artifact?
Methods: 1) Data from 2 HPLC studies of macular carotenoids were combined in order to obtain individual retinal distributions of lutein (L), meso-zeaxanthin (MZ) MPOD was obtained by HFP in both eyes of 10 subjects using 1° and 1.5° circular stimuli, and with annular stimuli of the same average radii. 3) Using HFP, the MPOD spectrum was obtained for 6 subjects in the wavelength range 410 to 680 nm. The rationale was that if spectral sensitivity is the same in the fovea and parafovea, the optical density should be zero above ~540 nm. 4) We simulated a group of 200 individuals aged 20 to 80 with randomly assigned MPOD between 0 and 1 such that the average MPOD did not depend on age. We calculated what would be the measured MPOD using LED-based HFP that does not correct for the aging lens.
Results: 1) L, Z and MZ distributions were similar. The peak value was highest for Z followed by MZ and then L. For eccentricities above 1 mm (~3°), the order became L (highest), Z then MZ (lowest). When normalized to the Z peak, MZ had an almost identical distribution to that of Z. 2) MPOD obtained with a 1.5° circular stimulus was always more than with an annular stimulus. With a 1° stimulus, this was true in 80% of cases. 3) MPOD appeared to exhibit a gradual rise with increasing wavelength above ~580 nm. 4) By simulating the measurement of MPOD, the "subjects" exhibited a slight decline in MPOD with age.
Conclusions: 1) MZ should not be singled out as the central carotenoid, based on the similarity of its distribution in the retina to those of L and Z. 2) HFP does not provide MPOD at the edge of the stimulus, rather at an eccentricity of about 70% of the stimulus radius. Eye movements may cause an apparent edge effect with smaller stimuli. 3) Spectral sensitivity may differ in the fovea and parafovea leading to a small underestimation of MPOD when measured by HFP. 4) A decline in MPOD with age could be, in part, an instrument-based artifact.

ZINC IN THE EYE AND THE VISUAL PATHWAY

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The eye, especially the retina and the underlying retinal pigment epithelium/choroid complex, contain high concentrations of zinc. Therefore, it is not surprising that several eye disorders are associated with altered zinc balance, and zinc supplementation has become a choice of treatment for diseases like age-related macular degeneration. Despite its importance in health and diseases of the eye it is still not well understood how zinc participates in cellular and molecular events and why zinc supplementation is beneficial. Therefore, discovering the metallome and understand the overall molecular and genetic changes associated with zinc in the eye may prove to be essential in combating eye diseases. Based on experiments on molecular, cellular and tissue levels we had proved that there are indeed direct effects of zinc supplementation on all these levels and now the task is to dissect how to make sense of these data and how supplementation could be made more efficient. Overall, given the important role for zinc in normal visual processing and its presumed involvement in the degeneration of the retina, the goal appears to be the restoration of optimal zinc balance in the eye which may slow the progression or even prevent the development of AMD.

DIFFERING XANTHOPHYLL CONTENT IN REGIONS OF ELDERLY HUMAN BRAIN

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Abstract: Xanthophylls (XN), lutein (L), and zeaxanthin (Z) have been implicated in reduced risk of degenerative diseases, including Alzheimer disease (AD).
Purpose: To measure and compare antioxidants, including L and Z, in brain regions of healthy elderly controls (HC) and those with AD.
Methods: Samples from HC and AD frontal lobe cortex (vulnerable, V) and occipital cortex (less-vulnerable, LV) were dissected into gray matter (GM) and white matter (WM) and analyzed for carotenoids, retinol and tocopherols by RP- HPLC.
Results: The method resolved at least 16 carotenoids with xanthophylls accounting for >70% in brain samples. Among these, beta-Cryptoxanthin (BCr) had the highest concentration. In both V ($p = 0.04$) and LV ($p = 0.03$) regions, Z was lower in AD vs HC while L was not significantly different. In LV regions, L and Z were higher in GM than WM. Several unidentified XN peaks in all samples were significantly altered in AD brains. "Peak 8" was elevated 2-5-fold in LV regions of AD ($p = 0.02$) and has been isolated for identification by HPLC-DAD-MS-MS. Peaks 2 and 4 were both lower ($p = 0.03$) in LV regions of AD vs HC and have been tentatively identified. No meso-Z was detected when isolated Z was separated into optical isomers.
Conclusions: Levels of Z and other XN peaks in some brain regions were associated with AD. BCr was the highest individual brain carotenoids. GM tended to have significantly higher XN than WM ($p = 0.08$).
Disclosures: NEC–Funding DG–ZeaVision, Patent CKD–none. Brain tissue donated by Mass. Alzheimer's Disease Research Ctr. Funded, in part, by Applied Food Biotechnology and ZeaVision.

MACULAR CAROTENOIDS, PSYCHOLOGICAL STRESS, AND GENERAL HEALTH STATUS IN YOUNG ADULTS

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Purpose: Chronic psychological stress is common in modern society, and leads to many negative health outcomes. The macular carotenoids lutein, zeaxanthin, and meso-zeaxanthin have been shown to promote wide-ranging, beneficial effects on a number of biological and physiologic systems in the body that are impacted by stress. Systemic inflammation is one of several deleterious effects of chronic psychological stress. Given lutein's role as an anti-inflammatory agent, and the well-established, inverse relationship between psychological stress and health, we aimed to evaluate the possibility that macular carotenoid level and supplementation with lutein could be related to subjects' perceived psychological stress, blood cortisol levels, and general health status.
Methods: A total of 151 young (mean age 21.5 years), healthy subjects were evaluated for this study. Macular pigment optical density (MPOD) at the 30' retinal locus was assessed via customized heterochromatic flicker photometry. Serum carotenoid levels were determined via HPLC. Psychological stress and general health status were determined via questionnaire. A subset of 27 subjects underwent a 3-month, double-blind, placebo-controlled lutein supplementation trial, during which MPOD, serum lutein, psychological stress, and general health status were evaluated every 2 weeks. Blood cortisol levels (evaluated with ELISA) were also assessed for this subset of subjects at baseline and at 3 months.
Results: In the large, cross-sectional analysis, MPOD was found to be significantly related to psychological stress ($r = -0.38$; $p<0.001$) and to symptoms of suboptimal health ($r = -0.37$; $p = 0.007$). In the smaller placebo-controlled lutein supplementation study, psychological stress and blood cortisol levels were significantly reduced in subjects supplemented with lutein ($t = 2.409$; $p = 0.032$; $t = 2.45$; $p = 0.03$, respectively). Placebos did not improve in either of these respects. Commensurate with the decrease in blood cortisol were significant increases in both serum lutein ($t = -3.8$; $p>0.001$) and MPOD ($t = -3.63$; $p<0.001$). Additionally, symptoms of suboptimal health decreased significantly in subjects consuming lutein ($t = 2.75$; $p = 0.029$), but not placebos ($p = 0.494$).
Conclusions: It appears that greater accumulation of macular carotenoids is related to benefits in terms of both psychological stress and general health status. Additionally, it appears that supplementation with lutein over a

period as short as 3 months can modify not only a person's perceived stress level, but also blood cortisol, which is typically elevated during periods of stress. Whether these effects are related to systemic reduction of oxidative stress and inflammation, or a more central (i.e., brain) accumulation of carotenoids is a question that warrants further study.
Disclosures: These studies were funded by Omniactive Health Technologies, Inc. and Fight For Sight.

THE SCIENCE OF MACULAR PIGMENT IN 2015 (KEYNOTE LECTURE)

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The constituents of macular pigment (MP) were not fully elucidated until several hundred years after the first description of the eponymous macula lutea, and there is consensus that diet represents the source of the regionalized and respective tissue concentrations of lutein (L) and zeaxanthin (Z), but the origins of the centrally dominant meso-zeaxanthin (MZ) remain a matter of debate. There is a growing consensus that the 3 carotenoids, respectively and collectively, contribute to visual performance through pre-receptoral absorption of visible blue light (and consequential attenuation of the deleterious optical impact of light scatter), and it is believed that MP's constituent carotenoids neutralize locally generated free radicals, thereby limiting oxidative stress at the macula. Any attempt to enhance our understanding of MP's role must take account of its optical (visual) and antioxidant (tissue-protective) properties, which are separate yet inextricably linked. In this lecture, the synthesis of the literature on MP's origins and roles will be reviewed.

CENTRAL RETINAL ENRICHMENT SUPPLEMENTATION TRIALS (CREST): REPORT 1

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Purpose: The Central Retinal Enrichment Supplementation Trials (CREST) is studying the impact of macular pigment (MP) enrichment, following supplementation with a formulation containing 10 mg lutein (L), 2 mg zeaxanthin (Z) and 10 mg meso-zeaxanthin (MZ), on visual performance in normal subjects (Trial 1, ISRCTN68270512) and in subjects with early age-related macular degeneration (AMD) (Trial 2, ISRCTN13894787). This lecture will present the CREST study design and the results from Trial 1 (CREST: Report 1).
Methods: The primary outcome measure is contrast sensitivity at 6 cpd. Secondary outcomes include glare disability, photostress recovery, MP, visual acuity, light scatter, retinal layer morphology, serum carotenoid concentrations, and cognitive function. In Trial 2, AMD morphology, reading acuity and speed are also being assessed. Inclusion criteria in Trial 1 includes: 18 years +, best-corrected visual acuity (BCVA) ≥6/6, spherical equivalence of refraction (SER) ≤5 D, not consumed supplements containing the macular carotenoids, no ocular pathology, MP at 0.25° <0.5 optical density units (ODU). Inclusion criteria for Trial 2 include: early stage AMD in at least one eye, BCVA ≥6/12, SER ≤5 D, not consumed supplements containing the macular carotenoids, no other ocular pathology.
Results: A total of 105 normal subjects have been recruited into Trial 1 and study visits will conclude in June 2015. A total of 121 subjects have been recruited into Trial 2 and study visits will conclude in June 2016.
Conclusions: CREST will add to the knowledge of the potential of the macular carotenoids L, Z and MZ for vision in normal subjects and in patients with AMD. CREST is the first study to test the effects of supplementation with all 3 macular carotenoids, including MZ, in the context of a large, double-blind, randomized clinical trial.
Disclosures: This project is funded by the European Research Council (ERC) under the CREST project (code: 281096). Professor Nolan holds a Howard Chair at Waterford Institute of Technology in Human Nutrition Research. Dr. Nolan and Dr. Beatty, within their capacity as a directors of Nutrasight Consultancy Ltd., carry out consultancy work for nutraceutical companies, including Bausch + Lomb, Heidelberg Engineering, MacuVision Europe Ltd., MacuHealth, DSM, and Kemin Health.

THE MACULAR CAROTENOIDS IN PRE- AND POST-NATAL DEVELOPMENT

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Purpose: To evaluate a role for the xanthophylls in human pre- and post-natal development. Carotenoids, in general, are thought to play an important role at the beginning of life as reflected by their presence in key reproductive and developing tissues: e.g., lutein in the forming macular, lycopene in the prostate gland or beta-carotene in the corpus luteum.
Methods: The existing literature is reviewed.
Results: Empirical data exists that support the following observations: (1) The macular xanthophylls enter neural tissue around the 8-10th week of prenatal development just as that tissue begins to form (mirrored in the yellow yolk of most oviparous species). (2) There, a likely function is their traditional roles of lowering oxidative and inflammatory stress but they may also serve to influence some basic cellular mechanisms as well (such as influences on stem cell differentiation and telomeres). (3) The xanthophylls are actively concentrated in cord blood and then colostrum (also often turned yellow) to be delivered to a rapidly developing macula and key nuclei of the brain. (4) Babies born premature and babies with poor diets have lower xanthophyll levels in their tissues. These lower levels have prompted concerns that this may increase risk of some developmental diseases (e.g., retinopathy of prematurity) or less than optimal development.
Conclusions: A confluence of studies in human embryology, anatomy, and comparative homology support the conclusion that xanthophylls play an important role in early human development.
Disclosures: BRH has received grant funding and speaker fees from Abbott Nutrition which makes an infant formula that contains lutein/zeaxanthin.

MESO-ZEAXANTHIN-ENRICHED EGGS AND THE IMPACT OF THEIR CONSUMPTION BY HUMANS: EGG XANTHOPHYLL INTERVENTION TRIAL (EXIT)

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Previous studies have shown that supplementation with the macular carotenoids meso-zeaxanthin (MZ), lutein (L) and zeaxanthin (Z) increase respective serum xanthophyll carotenoid concentrations, increase macular pigment (MP) levels, and improve contrast sensitivity (CS) in patients with age-related macular degeneration (AMD) and in subjects free of retinal disease. In this study, we wished to investigate the use of MZ-enriched eggs from hens fed with high amounts of MZ, L, and Z, as a vehicle to administer these xanthophylls to humans.
To prepare MZ-enriched eggs, we initially fed 8 xanthophyll preparations (L, Z, MZ, their diacetate salts and 2 mixtures) to Goldline hens at 140 mg/kg diet. All supplements increased the xanthophyll content of the yolks and the Z-diacetate produced the greatest response. However, the most cost-effective formulation in terms of egg production with the highest amounts of MZ and L was a 1:1 mixture of MZ and L diacetates, which generated eggs containing 1622 µg total non-esterified xanthophyll/yolk (~9.3 mg/100g) with an L:Z:MZ composition of ~8:5:10.
A single-blind study was then conducted in 2 groups of 25 subjects (mean age of 38 years), where subjects were recruited and fed at separate sites to receive 2 eggs daily (5 days/week for 8 weeks) from either control or xanthophyll-supplemented hens. To provide the eggs, 60 hens were fed either the 1:1 xanthophyll mixture (above) or the standard diet alone for 11 weeks and eggs were collected from 4-11 weeks (the total number of eggs collected was 6120) for use in the human trial. Serum xanthophyll concentrations, MPOD, visual acuity (VA) and CS in the volunteers were measured at baseline and 8 weeks. Serum concentrations of all three xanthophylls increased significantly in each group, but to a significantly greater extent in the xanthophyll-enriched group ($p<0.05$). There were no significant changes in MPOD, VA or CS in this 8 week study, but the increases seen in serum at 8 weeks following supplementation with the MZ-enriched eggs were markedly higher than what previous reports have shown using commercial food-supplement preparations when expressed per treatment dose. We therefore believe that these eggs offer potential for the development of a novel food to augment serum MZ in humans.