Clinical Evidence for Astaxanthin as an Ocular Carotenoid

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Background

- Astaxanthin is a red-orange xanthophyll carotenoid produced by microalgae like Haematococcus pluvialis[1]
- Astaxanthin has the highest singlet oxygen quenching capacity in vitro (Figure 1)[2]
- Astaxanthin spans the lipid bilayer to provide antioxidant coverage on either side and inside the membrane (Figure 2)[3]
- As much as 50% of membrane-bound astaxanthin resides in mitochondria, the cell's main source of free radicals (figure 3)[4]

Figure 1:
In-vitro Antioxidant Capacity of Ocular Carotenoids

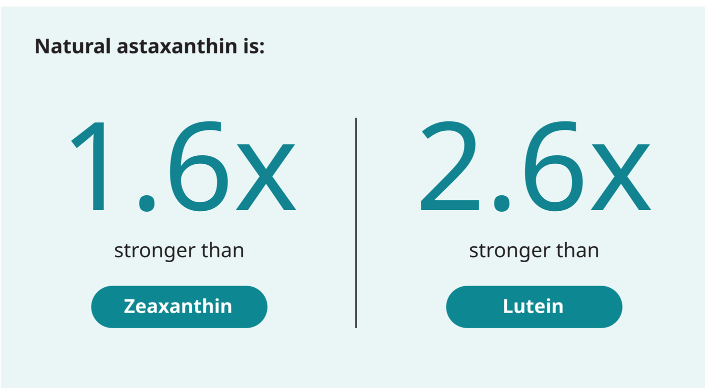


Figure 2:
Astaxanthin Spans Lipid Bilayer

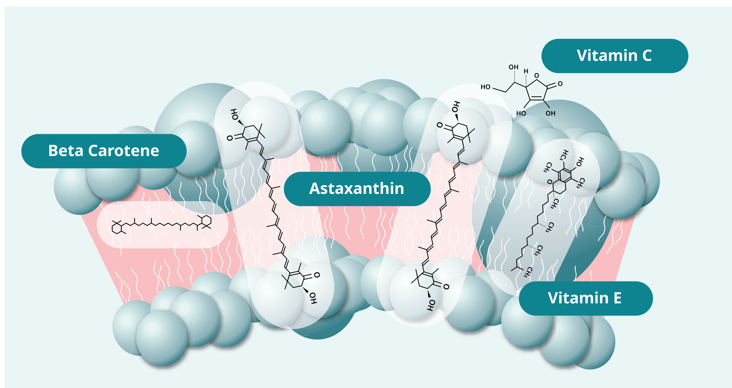


Figure 3:
Astaxanthin Mitochondrial Deposition

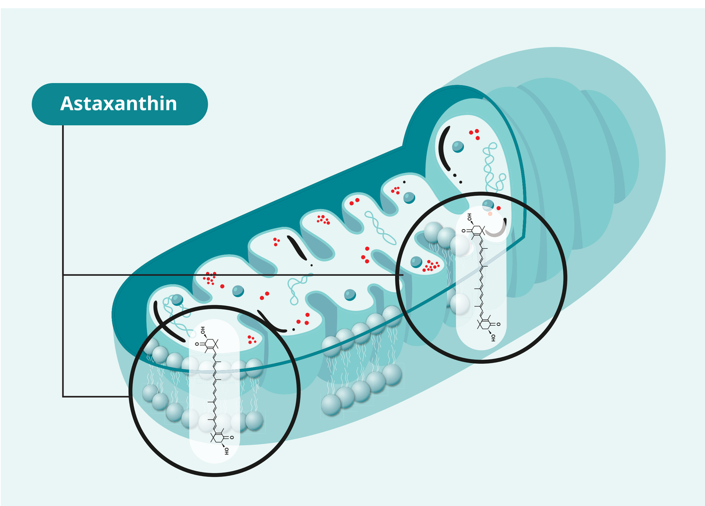
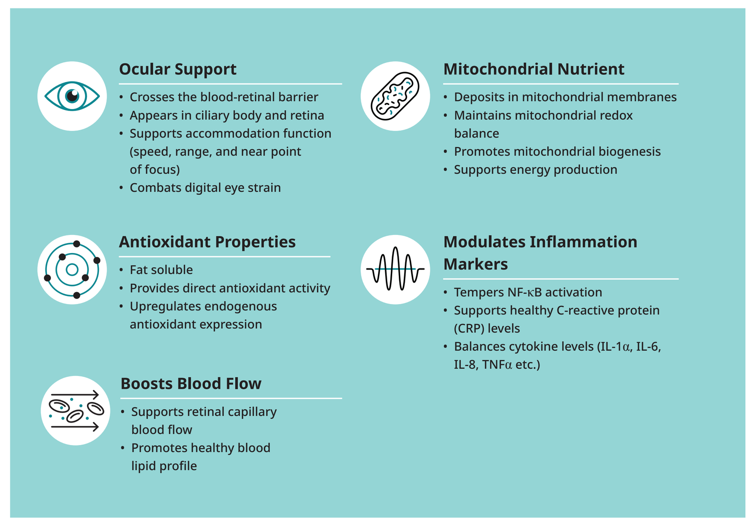


Figure 4:
Mechanism of Action of Astaxanthin



Astaxanthin in the Human Diet

- Lutein is broadly available in common foods such as leafy greens, herbs, vegetables, eggs, nuts, and select fruits.[5] Astaxanthin, by contrast, is obtained almost entirely from salmonid species, with only minor amounts in lobster, crab, and prawn.
- Average U.S. astaxanthin intake is very low at about 2 lbs of salmon per year, providing ~11 mg annually.[6,7]
- Clinically relevant exposures used in ocular studies (6 mg/day) correspond to ~127 lbs of wild sockeye salmon per year, highlighting a large dietary gap that requires supplementation to achieve.
- Population lutein intake remains modest at 2.36 mg/day, with mean plasma lutein/zeaxanthin concentrations around 310 nmol/L (Table 2).[8]

Table 1:
Dietary Sources of Astaxanthin

Source	Per Serving[6]
Sockeye Salmon	3.80 mg
Rainbow Trout	2.50 mg
Coho Salmon	2.10 mg
Shrimp (common freshwater, with shell)	1.80 mg
Atlantic Salmon	1.00 mg
King Salmon	0.54 mg
Daily Recommendation	12 mg

Table 2:
Typical Dietary Intake of Astaxanthin & Lutein

Carotenoid	Recommended intake	Daily dietary intake	Yearly dietary Intake	Availability
Astaxanthin	6 mg/day	0.03 mg/day	11 mg/year	Very limited seafood sources
Lutein	10 mg/day	2.36 mg/day	861 mg/year	Widely available in plant foods

Figure 5:
Clinically Relevant Dietary Servings of Lutein & Astaxanthin

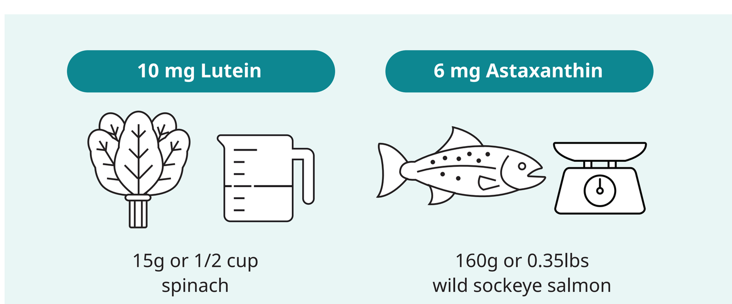


Table 3:
Carotenoid Concentration in Human Blood

Lutein (mg/day)	Plasma (nmol/L)	Duration	Reference
2.36	310	Meta-analysis (N/A)	(8)
Astaxanthin (mg/day)	**Plasma (nmol/L)**	**(weeks)**	**Reference**
1	12.3	4	(9)
1	18.9	12	(9)
3	14.4	4	(9)
3	62.4	12	(9)
6	46.7	2	(10)
6	59.6	4	(10)
6	35.7	12	(10)
12	44.9	12	(11)

Table 4:
Carotenoid Bioavailability

	Astaxanthin	Lutein
Model	Human, male, 26.5 y.o. (mean)	Human, male, 30.0 y.o. (mean)
Dosage	40mg, single dose, after breakfast	10mg, single dose, after breakfast
AUC (mg*h/L)	1.3 ± 0.5 (0-∞)	3.9 ± 3.0 (0-t)
C_{max} (μg/L)	55.2 ± 15.0	112.51 ± 75.7
$t_{1/2}$ (h)	16.7 ± 7.2	91.34 ± 26.1
t_{max} (h); median (min – max)	8 (8-8)	16 (6 – 48)
Reference	(12)	(13)

Astaxanthin Found in the Eye and Brain

Astaxanthin crosses the blood-retinal and blood-brain barriers

Table 5:
Astaxanthin Deposition in the Eye and Brain

Model	Delivery	Dose	Ocular structure	Time point	Concentration	Reference
Rabbit	Oral	100 mg/kg bw single dose	Iris/Ciliary body	t = 6 h	79.3 ng/g (C_{max}; n=6)	(14)
Rat	Intraperitoneal injections	37.5 mg/kg bw/injection every 12 hrs x 6	Retina	t = 24 h	0.17 µg/mg wet tissue (average, n=6)	(15)
bco2 -/- mouse	Oral	200 mg/kg bw	• Whole eye • Eye cup • Inner retina	t = 4 weeks	• 15-23 pmol/eye • 6-8 pmol/eye • 5-8 pmol/retina; (trans AX; n=16)	(16)
Rat	Gavage	100 mg/kg bw	Brain	t = 24 h	0.123 ug/g wet (n=3)	(17)

Figure 6:
Astaxanthin Supports Accommodative Function

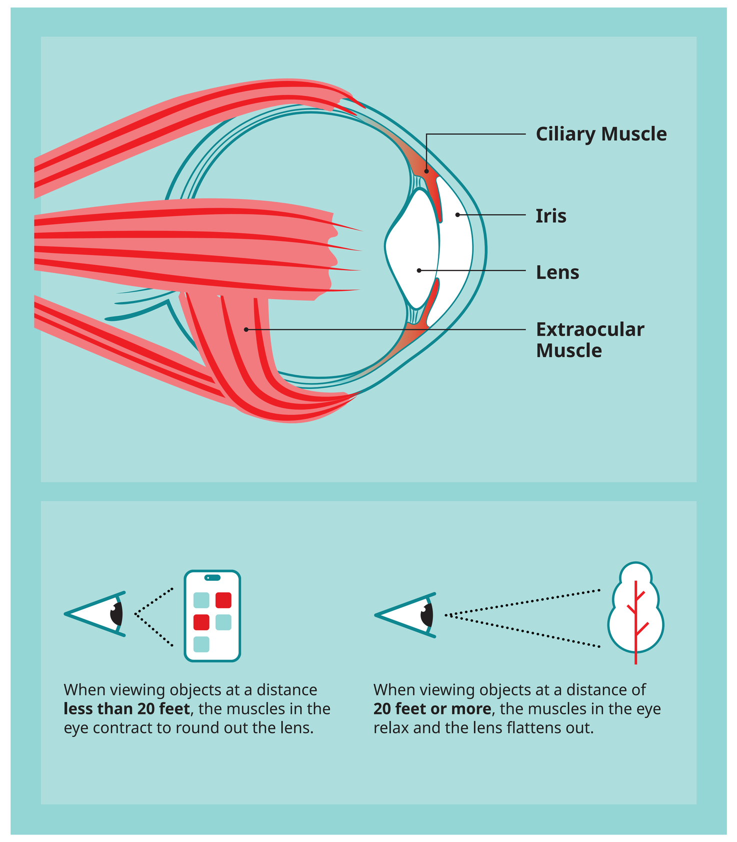


Table 6:
Clinical Outcomes of Astaxanthin (AstaReal®) Supplementation on Accommodation in Adults

Astaxanthin (AstaReal®) Dose	Duration	Accommodation amplitude (D)	Positive Accommodation	Negative Accommodation	Reference
12 mg/day	4 weeks	N.S.	66% (2 sec) faster; p<0.01 vs. baseline	N.S.	(18)
12 mg/day	4 weeks	+27% (+1.0 D); p<0.05 vs. baseline	+40% (0.9 D/sec); p<0.05 vs. baseline	N.S.	(19)
9 mg/day	4 weeks	+17% (+0.67 D); p<0.01 vs. baseline, p<0.05 vs. placebo	N/A	N/A	(20)
6 mg/day	2 weeks	N/A	N.S.	10% (0.12 sec) faster; p<0.05 vs. placebo	(21)
6 mg/day	4 weeks	+13% (+0.4 D); p<0.05 vs. baseline	N/A	N/A	(22)
6 mg/day	4 weeks	N.S.	+27% (0.8 D/sec); p<0.05 vs. baseline	+17% (0.9 D/sec); p<0.01 vs. baseline, p<0.05 vs. placebo	(19)
6 mg/day	4 weeks	+54% (+1.9 D); p<0.01 vs. baseline	+45% (1.3 D/sec); p<0.01 vs. baseline	+50% (1.9 D/sec); p<0.01 vs. baseline	(23)
5 mg/day	4 weeks	+21.7% (+0.5D); p<0.01 vs. baseline	N/A	N/A	(24)
4 mg/day	4 weeks	N.S.	17% (0.3 sec) faster; p<0.05 vs. baseline	N.S.	(18)
2 mg/day	4 weeks	N.S.	N.S.	N.S.	(18)

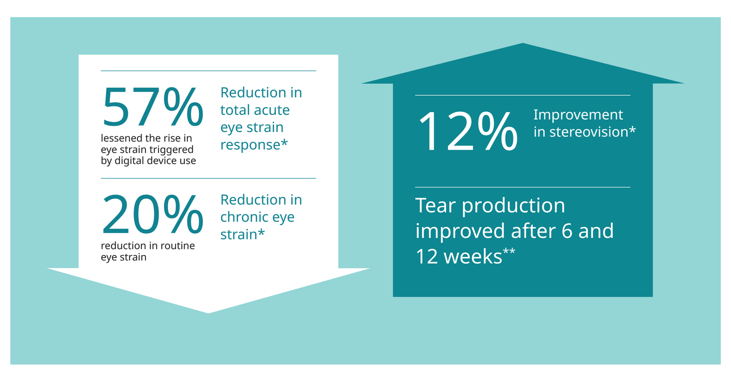
N.S. – not significant **N/A** – not available **D** – diopter; a unit of refractive power
Positive accommodation – adjustment from a distant to a near focal point
Negative accommodation – adjustment from a near to a distant focal point

Table 7:
Computer Vision Syndrome Outcomes in Adults

Dose	Intake Period	# Participants (Total)	Age	Accommodation result	Reference
9 mg/day	4 weeks	82	30-45 (average 39)	"eyestrain" (p<0.05 @4wk), "hazy vision" (p<0.05 @2wk, p<0.01 @4wk), "flickering images" (p<0.05 @4wk), "my shoulders/back feel stiff" (p<0.05 @2wk and @4wk) significantly improved in AX vs. control.	(20)
6 mg/day	4 weeks	36	Average 41	Improvement tendency in "My eyes tire easily," a significant improvement in "My eyes get red easily" and an improvement tendency in "My eyes can't focus properly" in AX vs. control.	(10)
6 mg/day	4 weeks	48	30-45 (average 37)	Significant improvement in "dimness of sight" and "stiff shoulders and back," and an improvement tendency for "heavy head" in AX vs. placebo.	(22)
6 and 12 mg/day	4 weeks	30	23-49 (average 35)	After 4 weeks AX 6mg/day group showed significant improvement compared to 0 weeks (which were not observed in placebo group) for: "My eyes hurt," p<0.05; "My eyesight is dim," p<0.01; "My eyes get red easily," p<0.05; "My shoulders and waist are stiff," p<0.01; "I get irritated easily," p<0.05; "My head becomes heavy easily," p<0.05; "The insides of my eyes are painful," p<0.05; "My eyes get bleary," p<0.01; «My eyelids twitch," p<0.05. After 4 weeks AX 12mg/day group showed significant improvement compared to 0 weeks (which were not observed in placebo group) for: "The insides of my eyes are painful," p<0.05; "My eyes get bleary," p<0.05; "Light is too bright" p<0.05.	(19)
6 mg/day	4 weeks	39	20-60 (average 30)	"blear-eye feeling" and "tendency of irritation" significantly improved in AX vs. placebo (p<0.05)	(23)
6 mg/day	2 weeks	9	30-42	A 0 weeks, four subjects stated their eyes had become tired because of VDT work, but after 2 weeks AX, this had decreased to two subjects. Following 20min rest after VDT work, at 0 weeks no subjects reported improvement in fatigue as the result of rest, but after 2 weeks AX, two subjects responded their eyes had recovered.	(24)
12 mg/day	8 weeks	20	Average 57	Significant improvement in "tired eyes" "stiff shoulders" after 8 weeks compared to 0 weeks (p<0.05).	(25)
5 mg/day	4 weeks	39	Average 48	At beginning of study all participants complained of eye strain. After 4 weeks 7 of 13 VDT workers at 0mg/day AX no longer reported eye strain, while 12 of 13 VDT workers at 5mg/day AX no longer reported eye strain. Between group difference was statistically significant (p<0.05).	(26)

Astaxanthin Supplementation in Pediatric Computer Vision Syndrome

Figure 7:
CVS Outcomes in Children After Astaxanthin Supplementation



A study on children aged 10-14 supplementing with 4mg/day of AstaReal® Astaxanthin showed reduced CVS symptoms. After 12 weeks, chronic symptoms dropped by 20%, and acute symptoms triggered by 60 minutes of gaming decreased by 57% compared to placebo. Stereovision, an objective measure of visual function, improved by 12% in the astaxanthin group. Tear production also improved significantly at six and 12 weeks compared to baseline, with no changes in the placebo group.[27]

Astaxanthin Supports Retinal Blood Flow

Two randomized, placebo-controlled trials demonstrate short-term improvements in ocular microcirculation with AstaReal® astaxanthin.

↑ 9-11%

Astaxanthin increased capillary blood flow 9-11% compared to baseline (p<0.01; n=36; mean age 41)

Dose: 6 mg/day AstaReal® vs placebo for 4 weeks.[10]

↑ 15%

Macular blood flow velocity increased 15% in the AstaReal® group vs. baseline (p<0.05; n=20; mean age 38)

Dose: 12 mg/day AstaReal® vs placebo for 4 weeks[28]

Conclusion: Across two independent 4-week studies, AstaReal® astaxanthin (6–12 mg/day) produced statistically significant increases in retinal and macular microvascular blood flow.

CARMIS Study

A 24-month prospective open-label randomized study involving 145 eligible subjects (59 men and 86 women; mean age ± SD, 72.5±7 years; median 74 years). Oral daily supplementation of vitamin C (180 mg), vitamin E (30 mg), zinc (22.5 mg), copper (1 mg), lutein (10 mg), zeaxanthin (1 mg), and astaxanthin (4 mg).

Patients in the treated group showed stabilization of VA with significantly (p=0.003) better VA scores (81.4±7.2) compared to the nontreated group (76.8±8.9) at 24-month follow-up. An improvement in CS (p=0.001) and final mean NEI VFQ-25 composite scores at 12 and 24 months higher in treated group compared to nontreated group were also shown (p<0.001)[29]

Post-Operative Outcomes for Cataracts

Following cataract surgery on one eye, all participants began treatment with **AstaReal® 6 mg/day** for 2 weeks, followed by surgery on the other eye.

Table 8:
Post-Operative Redox Markers in Men with Cataracts

Dose	Intake Period	# Participants	Age	Antioxidant Capacity Result	Reference
6mg/day	2 weeks	35	Average 71	Increased superoxide scavenging activity, reduced total hydroperoxides	(30)
6mg/day	2 weeks	35	Average 71	Increased superoxide scavenging activity, reduced total hydroperoxides	(31)
6mg/day	2 weeks	35	Average 70.6	Reduced total hydroperoxides	(32)
6mg/day	2 weeks	35	Average 70	Increased superoxide scavenging activity	(33)
6mg/day	2 weeks	37	Average 72	Lower flare intensity after surgery (light reflecting off proteins in aqueous humor)	(34)

Ocular Surface

Supplement containing anthocyanosides, astaxanthin (4 mg/day), vitamins A, C, and E, and selected herbal extracts impacted dry eye related metrics after 8 weeks:[35]

- Schirmer's test without topical anesthesia in treatment 7.79 ± 4.50 vs placebo 5.72 ± 3.80 mm/5 min; p = 0.027.
- No between-group difference was observed in Schirmer's test performed under 0.5% proparacaine anesthesia.
- TBUT significant differences between groups at 4 weeks (p<0.05) after supplementation;
- TBUS significantly reduced only in treatment group at 12 weeks compared to 4 weeks (p<0.05), and at 16 weeks compared to both 8 weeks and 4 weeks (p<0.001).
- Tear ROS decreased after treatment (p<0.05).
- Subjective improvement of dry eye symptoms between groups (p<0.05).

Conclusions and Future Directions

- Astaxanthin is an ocular carotenoid found in the ciliary body and retina.
- Astaxanthin supplementation at 6 mg/day supported accommodative function and reduced eye strain after 4 weeks in adults.
- Astaxanthin supplementation at 4 mg/day supported stereopsis and reduced eye strain after 12 weeks in children 10 -14 years old.
- Astaxanthin increased choroidal blood flow
- Astaxanthin formulation improved VA, CS, and NEI VFQ-25 score after 2 years
- Astaxanthin supported redox balance following cataract surgery
- Astaxanthin formulation modulated markers of dry eye, including Shirmer's, TBUT, and ROS level in tears.

Contact Information and e-book download

To access the e-book and more technical information on astaxanthin research, ingredient sourcing, and formulation strategy, visit AstaReal's Vision Care resource hub: https://astareal.com/Vision-care.html.

To discuss scientific data, product development pathways, or commercial considerations directly with the AstaReal team, contact contact@astarealusa.com.

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