Supplementary data

Table S1 List of gene primers used in qRT-PCR.

Primer	Sequences (5’ to 3’)
pmp-3 forward	GTTCCCGTGTTCATCACTCAT
pmp-3 reverse	ACACCGTCGAGAAGCTGTAGA
daf-2 forward	TCAAATGAACGAGGAGCCG
daf-2 reverse	TGGAACACCGTAGGAAGAGC
age-1 forward	CGGAAAGACCAAACTTGGGATC
age-1 reverse	CGTAGGCTTCGACGCATAACG
akt-1 forward	CAAAGCCTAAGGAAGGACAACC
akt-1 reverse	CATGAATCCAACGCTGACGAAC
akt-2 forward	ACATTCAGCGAAGCACGAACA
akt-2 reverse	TACATGACCACTCCGACTCCC
daf-16 forward	TCGTCGTCTCGTGTTTCTCCA
daf-16 reverse	TTCCATAGGCACCCGGTAGTG
pha-4 forward	GAACCACGCAAGCACAGATG
pha-4 reverse	CGGGTTGGTGGAGCTGTAAA
ifg-1 forward	AGCAAAGAGATCGTATGCAC
ifg-1 reverse	ACAAACTTCAATAACCGCAG
let-363 forward	CACAGGCGAACTAATACCGT
let-363 reverse	TTTCCGAGTTGCTTGATGAT
rsks-1 forward	GTTTGTGGGATTCACC
rsks-1 reverse	TGGCTTTCTCGGGCTCTT
lgg-1 forward	AACAACTTTGAGAAGCGTCGTGCC
lgg-1 reverse	ATCTTCTGGACGAAGTTGGATGCG
ncr-1 forward	AGGCCATGGAAGTTCAGAGA
ncr-1 reverse	GCTGGCGTCCAGTAAAGAAG
asm-1 forward	ACGATTCTGGCCAACATGGT
asm-1 reverse	AAGTCCATCCATAACTTGTG
atg-5 forward	CTGGCGGAACTCACGGAG
atg-5 reverse	CGCTTGATCGTAGATCAC
vps-34 forward	GTCGATTCTGCCTACCGGAT

vps-34 reverse	GGAGGCGTTGTTCGATCTTG
lmp-1 forward	ATCCGCCACCGCTTCGCATT
lmp-1 reverse	TCGAGCTCCCACTCTTTGGCG
skn-1 forward	TTTTGCCTCCTCTCTTCTGGC
skn-1 reverse	GGCGTATGGATGTTGGTGATG

Table S2 Statistical analyses of the lifespan of *C. elegans* treated with astaxanthin

Conc. (μg/mL)	Number	Mean lifespan (d)	Max. lifespan (d)
0	223	15.2 ± 0.2	23.3 ± 1.7
0.5	224	15.3 ± 0.3	24.3 ± 2.1
1	209	15.4 ± 0.3	25.7 ± 1.5
5	227	16.0 ± 0.3*	25.7 ± 0.8
10	210	16.1 ± 0.3*	26.0 ±1.0
20	225	17.0 ± 0.3*	27.3 ±0.7*

Worms from three independent experiments were combined for the analyses. The mean lifespans were analyzed by the Kaplan–Meir survival analysis of SPSS 22.0 and expressed as mean ± SEM. The maximum lifespans were the average maximum lifespan of three independent experiments. *Significantly different from the control-treated worms (p<0.05).

Table S3 Effects of astaxanthin on lifespan in *skn-1* RNAi worms

Group	Number	Mean lifespan (d)	Max. lifespan (d)
L4440 + Control	194	16.1 ± 0.3^{b}	25.3 ± 0.7^{b}
L4440 + Astaxanthin	204	17.7 ± 0.2^{a}	28.3 ± 0.3^{a}
skn-1 RNAi + Control	219	13.7 ± 0.1^{c}	19.0 ± 1.0^{c}
skn-1 RNAi + Astaxanthin	217	13.8 ± 0.2^{c}	19.3 ± 0.3^{c}

Worms from three independent experiments were combined for the analyses. The mean lifespans were analyzed by the Kaplan–Meir survival analysis of SPSS 22.0 and expressed as mean ± SEM. The maximum lifespans were the average maximum lifespan of three independent experiments. Different letters denote mean values that are statistically different at p<0.05.

Table S4 Lifespan of *C. elegans* treated with astaxanthin in the presence of chloroquine

Group	Number	Mean lifespan (d)	Max. lifespan (d)
Control	240	14.2 ± 0.1^{c}	20.0 ± 1.0^{b}
Astaxanthin	226	16.0 ± 0.2^{a}	23.7 ± 0.3^{a}
Chloroquine	239	14.9 ± 0.2^{b}	21.7 ± 0.7^{ab}
Astaxanthin + Chloroquine	234	14.3 ± 0.2^{c}	22.7 ± 1.2^{ab}

Worms from three independent experiments were combined for the analyses. The mean lifespans

were analyzed by the Kaplan–Meir survival analysis of SPSS 22.0 and expressed as mean ± SEM. The maximum lifespans were the average maximum lifespan of three independent experiments. Different letters denote mean values that are statistically different at $p<0.05$.

Table S5 Effects of astaxanthin on lifespan in *pha-4* RNAi worms

Group	Number	Mean lifespan (d)	Max. lifespan (d)
L4440 + Control	246	16.5 ± 0.2^{b}	25.7 ± 0.3^{b}
L4440 + Astaxanthin	260	17.8 ± 0.3^{a}	29.7 ± 0.3^{a}
pha-4 RNAi + Control	254	15.5 ± 0.2^{c}	23.0 ± 1.0^{c}
pha-4 RNAi + Astaxanthin	255	15.6 ± 0.2^{c}	25.0 ± 0.6^{bc}

Worms from three independent experiments were combined for the analyses. The mean lifespans were analyzed by the Kaplan–Meir survival analysis of SPSS 22.0 and expressed as mean ± SEM. The maximum lifespans were the average maximum lifespan of three independent experiments. Different letters denote mean values that are statistically different at $p<0.05$.

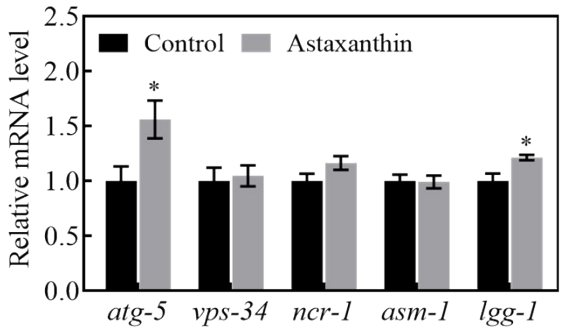

Fig. S1. Effects of astaxanthin (20 μg/mL) on the expression of ALP-related genes in *skn-1* RNAi worms. The *skn-1* RNAi worms were treated with astaxanthin for 6 d before RNA extraction. The mRNA levels were determined by qRT-PCR and normalized to the expression of *pmp-3*.