

**Table S1.** Summary of full general linear models of the effect of carotenoid supplementation on plasma lutein,  $\beta$ -carotene, vitamin E, total antioxidant capacity, reactive oxygen metabolite (ROM), oxidative damage to lipids (MDA) and proteins (carbonyl group), body mass, tarsus length and inflammatory immune response to phytohaemagglutinin (PHA) of yellow legged gull chicks before Paraquat (PQ) administration.

Dependent variable	Source of variation	<i>d.f.</i>	Estimate $\pm$ SE	<i>F</i>	<i>P</i>	
Lutein ( $\mu\text{g ml}^{-1}$ )	Intercept		4.68 $\pm$ 3.04			
	Treatment	$\beta$ -carotene	2,70	-0.37 $\pm$ 0.07	49.78	<b>&lt;0.001</b>
		No carotenoid		-0.44 $\pm$ 0.07		
	Sex	Female	1,70	-0.03 $\pm$ 0.07	0.01	0.989
	Hatching date		1,70	-1.84 $\pm$ 1.37	1.80	0.184
	Lutein at hatching		1,70	0.14 $\pm$ 0.07	3.69	0.059
	Brood size		1,70	-0.01 $\pm$ 0.04	0.01	0.950
	Treatment $\times$ Sex	Female, $\beta$ -carotene	2,70	-0.01 $\pm$ 0.09	1.05	0.354
		Female, no carotenoid		0.10 $\pm$ 0.08		
$\beta$ -carotene ( $\mu\text{g ml}^{-1}$ )	Intercept		-2.39 $\pm$ 2.06			
	Treatment	$\beta$ -carotene	2,70	0.18 $\pm$ 0.05	35.83	<b>&lt;0.001</b>
		No carotenoid		-0.02 $\pm$ 0.05		
	Sex	Female	1,70	-0.02 $\pm$ 0.05	0.31	0.579
	Hatching date		1,70	1.07 $\pm$ 0.93	1.33	0.253
	$\beta$ -carotene at hatching		1,70	-0.01 $\pm$ 0.14	0.01	0.944
	Brood size		1,70	0.05 $\pm$ 0.03	3.62	0.061
	Treatment $\times$ Sex	Female, $\beta$ -carotene	2,70	0.07 $\pm$ 0.06	0.74	0.483
		Female, no carotenoid		0.02 $\pm$ 0.06		
Vitamin E ( $\mu\text{g ml}^{-1}$ )	Intercept		-82.13 $\pm$ 57.28			
	Treatment	$\beta$ -carotene	2,67	0.10 $\pm$ 1.31	0.16	0.853
		No carotenoid		-0.65 $\pm$ 1.30		
	Sex	Female	1,67	-0.73 $\pm$ 1.29	1.72	0.194
	Hatching date		1,67	41.63 $\pm$ 25.75	2.61	0.111
	Vitamin E at hatching		1,67	0.05 $\pm$ 0.04	1.12	0.295
	Brood size		1,67	0.23 $\pm$ 0.73	0.09	0.761
	Treatment $\times$ Sex	Female, $\beta$ -carotene	2,67	-1.24 $\pm$ 1.80	0.75	0.478
		Female, no carotenoid		0.72 $\pm$ 1.60		
Total antioxidant capacity (mmol of Trolox equivalents $\text{l}^{-1}$ )	Intercept		-9.94 $\pm$ 4.60			
	Treatment	$\beta$ -carotene	2,53	0.02 $\pm$ 0.11	0.35	0.710
		No carotenoid		0.01 $\pm$ 0.11		
	Sex	Female	1,53	0.02 $\pm$ 0.11	0.63	0.431
	Hatching date		1,53	4.82 $\pm$ 2.07	5.40	<b>0.024</b>
	MDA at hatching		1,53	-0.05 $\pm$ 0.23	0.04	0.836
	Brood size		1,53	-0.08 $\pm$ 0.06	1.52	0.222
	Treatment $\times$ Sex	Female, $\beta$ -carotene	2,53	-0.17 $\pm$ 0.16	0.60	0.552
		Female, no carotenoid		-0.04 $\pm$ 0.14		
ROM (mmol $\text{H}_2\text{O}_2 \text{l}^{-1}$ )	Intercept		138.71 $\pm$ 91.08			
	Treatment	$\beta$ -carotene	2,68	-3.54 $\pm$ 2.04	0.78	0.461
		No carotenoid		-1.97 $\pm$ 2.05		
	Sex	Female	1,68	-1.77 $\pm$ 2.03	0.01	0.990
	Hatching date		1,68	-57.60 $\pm$ 40.96	1.98	0.164
	MDA at hatching		1,68	0.49 $\pm$ 4.56	0.01	0.914
	Brood size		1,68	1.03 $\pm$ 1.18	0.77	0.383
	Treatment $\times$ Sex	Female, $\beta$ -carotene	2,68	4.51 $\pm$ 2.81	1.55	0.219
		Female, no carotenoid		0.76 $\pm$ 2.51		

Significant values are represented in bold type

**Table S1** (continue)

Dependent variable	Source of variation	<i>d.f.</i>	Estimate±SE	<i>F</i>	<i>P</i>	
MDA (µg MDA ml <sup>-1</sup> )	Intercept		25.87±25.04			
	Treatment	β-carotene	2,38	0.29±0.55	0.36	0.699
		No carotenoid		-0.17±0.57		
	Sex	Female	1,38	0.16±0.58	0.82	0.372
	Hatching date		1,38	-10.80±11.34	0.91	0.347
	MDA at hatching		1,38	0.39±1.46	0.07	0.789
	Brood size		1,38	-0.02±0.31	0.01	0.951
	Plasma lipids		1,38	-0.25±0.18	1.94	0.172
	Treatment × Sex	Female, β-carotene	2,38	-1.32±0.93	1.39	0.261
Female, no carotenoid			-0.01±0.71			
Carbonyl group (nmol ml <sup>-1</sup> )	Intercept		16.64±8.03			
	Treatment	β-carotene	2,60	-0.27±0.18	1.36	0.264
		No carotenoid		-0.25±0.19		
	Sex	Female	1,60	-0.15±0.19	0.22	0.638
	Hatching date		1,60	-7.11±3.59	3.91	0.052
	MDA at hatching		1,60	-0.34±0.38	0.82	0.368
	Brood size		1,60	-0.09±0.10	0.95	0.333
	Plasma protein		1,60	0.18±0.26	0.48	0.492
	Treatment × Sex	Female, β-carotene	2,60	0.19±0.24	0.30	0.743
Female, no carotenoid			0.13±0.23			
Body mass (g)	Intercept		1098.84±540.22			
	Treatment	β-carotene	2,65	-6.57±10.71	0.13	0.878
		No carotenoid		-14.54±11.00		
	Sex	Female	1,65	-15.79±10.56	0.92	0.341
	Hatching date		1,65	-483.63±243.11	3.96	0.051
	Body mass at hatching		1,65	1.48±0.56	6.95	<b>0.010</b>
	Brood size		1,65	-8.27±6.48	1.63	0.207
	Treatment × Sex	Female, β-carotene	2,65	5.31±14.86	1.90	0.158
		Female, no carotenoid		25.10±13.93		
Tarsus length (mm)	Intercept		82.27±49.55			
	Treatment	β-carotene	2,65	-0.18±0.96	0.27	0.765
		No carotenoid		-0.21±0.99		
	Sex	Female	1,65	-0.96±0.96	2.01	0.162
	Hatching date		1,65	-33.63±21.97	2.34	0.131
	Tarsus at hatching		1,65	1.00±0.23	18.67	<b>&lt;0.001</b>
	Brood size		1,65	-1.13±0.59	3.66	0.060
	Treatment × Sex	Female, β-carotene	2,65	-0.17±1.34	0.37	0.693
		Female, no carotenoid		0.80±1.23		
Inflammatory immune response to PHA at 8 days if life (mm)	Intercept		-0.99±9.55			
	Treatment	β-carotene	2,47	0.14±0.18	8.23	<b>0.001</b>
		No carotenoid		-0.38±0.20		
	Sex	Female	1,47	0.05±0.19	1.78	0.189
	Hatching date		1,47	0.16±4.30	0.01	0.971
	Body mass at hatching		1,47	0.01±0.01	1.85	0.181
	Brood size		1,47	0.14±0.11	1.73	0.194
	Treatment × Sex	Female, β-carotene	2,47	0.08±0.26	0.34	0.713
		Female, no carotenoid		0.21±0.26		

Significant values are represented in bold type

**Table S2.** Summary of full mixed models of the effect of carotenoid supplementation on plasma lutein,  $\beta$ -carotene, vitamin E, total antioxidant capacity, reactive oxygen metabolite (ROM), oxidative damage to lipids (MDA) and proteins (carbonyl group), body mass and tarsus length of yellow legged gull chicks after Paraquat (PQ) administration (at 9 and 12 days of age).

Dependent variable	Source of variation	<i>d.f.</i>	Estimate $\pm$ SE	<i>F</i>	<i>P</i>	
Lutein ( $\mu\text{g ml}^{-1}$ )	Intercept		10.77 $\pm$ 4.24			
	Treatment	$\beta$ -carotene+PQ	3,36.70	0.09 $\pm$ 0.09	33.83	<b>&lt;0.001</b>
		No carotenoid-no PQ		-0.02 $\pm$ 0.13		
		Lutein+PQ		0.40 $\pm$ 0.09		
	Sex	Female	1,37.62	-0.04 $\pm$ 0.09	0.01	0.942
		Age	9 days of age	1,38.35	0.15 $\pm$ 0.07	7.59
	Hatching date		1,40.12	-4.84 $\pm$ 1.92	6.39	<b>0.016</b>
	Brood size		1,31.15	-0.04 $\pm$ 0.04	1.00	0.324
	Lutein at hatching		1,33.02	0.14 $\pm$ 0.08	2.89	0.099
	Treatment $\times$ Age	Age 9, $\beta$ -carotene+PQ	3,37.98	-0.21 $\pm$ 0.07	2.75	0.056
		Age 9, no carotenoid-no PQ		-0.09 $\pm$ 0.09		
		Age 9, lutein+PQ		-0.07 $\pm$ 0.07		
	Treatment $\times$ Sex	Female, $\beta$ -carotene+PQ	3,34.74	-0.04 $\pm$ 0.12	1.28	0.297
		Female, no carotenoid-no PQ		0.01 $\pm$ 0.14		
		Female, lutein+PQ		0.15 $\pm$ 0.12		
	Sex $\times$ Age	Age 9, female	1,37.96	0.03 $\pm$ 0.06	0.30	0.589
	$\beta$ -carotene ( $\mu\text{g ml}^{-1}$ )	Intercept		-0.34 $\pm$ 2.38		
Treatment		$\beta$ -carotene+PQ	3,25.71	0.12 $\pm$ 0.07	10.14	<b>&lt;0.001</b>
		No carotenoid-no PQ		-0.06 $\pm$ 0.09		
		Lutein+PQ		0.05 $\pm$ 0.07		
Sex		Female	1,27.29	0.12 $\pm$ 0.06	5.20	<b>0.031</b>
		Age	9 days of age	1,32.40	0.03 $\pm$ 0.08	0.01
Hatching date			1,33.96	0.21 $\pm$ 1.08	0.04	0.849
Brood size			1,28.08	-0.09 $\pm$ 0.14	0.38	0.541
$\beta$ -carotene at hatching			1,23.67	-0.03 $\pm$ 0.02	2.53	0.125
Treatment $\times$ Age		Age 9, $\beta$ -carotene+PQ	3,31.99	0.09 $\pm$ 0.09	0.88	0.462
		Age 9, no carotenoid-no PQ		0.03 $\pm$ 0.09		
		Age 9, lutein+PQ		-0.04 $\pm$ 0.09		
Treatment $\times$ Sex		Female, $\beta$ -carotene+PQ	3,27.59	-0.03 $\pm$ 0.07	0.30	0.823
		Female, no carotenoid-no PQ		0.04 $\pm$ 0.08		
		Female, lutein+PQ		-0.03 $\pm$ 0.07		
Sex $\times$ Age		Age 9, female	1,31.95	-0.11 $\pm$ 0.06	2.79	0.105

Significant values are represented in bold type

**Table S2.** (continue)

Dependent variable	Source of variation	<i>df</i>	Estimate±SE	<i>F</i>	<i>P</i>	
Vitamin E (µg ml <sup>-1</sup> )	Intercept		60.97±63.00			
	Treatment	β-carotene+PQ	3,26.03	5.08±1.87	5.51	<b>0.005</b>
		No carotenoid-no PQ		4.90±2.32		
		Lutein+PQ		5.33±1.69		
	Sex	Female	1,28.17	3.06±1.66	0.27	0.608
		Age	9 days of age	1,32.36	1.98±1.60	2.25
	Hatching date		1,32.86	-26.12±28.58	0.84	0.367
	Brood size		1,23.17	-0.52±0.58	0.79	0.382
	Vitamin E at hatching		1,29.18	0.05±0.04	1.17	0.289
		Treatment × Age	Age 9, β-carotene+PQ	3,31.73	-2.70±1.75	0.92
	Age 9, no carotenoid-no PQ			-1.42±1.75		
	Age 9, lutein+PQ			-0.69±1.73		
	Treatment × Sex	Female, β-carotene+PQ	3,26.39	-3.51±2.09	1.65	0.202
		Female, no carotenoid-no PQ		-5.11±2.35		
Female, lutein+PQ			-2.86±1.86			
Sex × Age	Age 9, female	1,31.81	0.31±1.29	0.06	0.815	
Total antioxidant capacity (mmol of Trolox equivalents l <sup>-1</sup> )	Intercept		-6.08±4.75			
	Treatment	β-carotene+PQ	3,24.98	0.13±0.12	0.82	0.497
		No carotenoid-no PQ		0.03±0.17		
		Lutein+PQ		0.05±0.11		
	Sex	Female	1,25.02	-0.04±0.11	4.65	<b>0.041</b>
		Age	9 days of age	1,30.09	0.03±0.11	0.18
	Hatching date		1,32.48	3.02±2.15	1.96	0.171
	Brood size		1,24.02	-0.03±0.05	0.38	0.542
	MDA at hatching		1,25.81	-0.24±0.22	1.17	0.290
		Treatment × Age	Age 9, β-carotene+PQ	3,29.67	-0.19±0.11	3.61
	Age 9, no carotenoid-no PQ			0.06±0.11		
	Age 9, lutein+PQ			0.14±0.10		
	Treatment × Sex	Female, β-carotene+PQ	3,24.53	-0.01±0.15	0.40	0.752
		Female, no carotenoid-no PQ		-0.18±0.18		
Female, lutein+PQ			-0.08±0.13			
Sex × Age	Age 9, female	1,28.59	-0.03±0.08	0.11	0.749	
ROM (mmol H <sub>2</sub> O <sub>2</sub> l <sup>-1</sup> ),	Intercept		119.91±103.70			
	Treatment	β-carotene+PQ	3,28.619	-0.99±2.61	2.94	0.050
		No carotenoid-no PQ		7.56±3.49		
		Lutein+PQ		2.77±2.50		
	Sex	Female	1,29.40	3.36±2.34	0.01	0.991
		Age	9 days of age	1,33.66	-0.05±2.45	0.55
	Hatching date		1,35.99	-50.75±47.01	1.17	0.288
	Brood size		1,25.47	-1.12±0.95	1.39	0.250
	MDA at hatching		1,28.58	9.02±4.63	3.79	0.061
		Treatment × Age	Age 9, β-carotene+PQ	3,33.09	0.95±2.78	1.06
	Age 9, no carotenoid-no PQ			2.44±2.93		
	Age 9, lutein+PQ			-2.50±2.77		
	Treatment × Sex	Female, β-carotene+PQ	3,28.46	-0.08±2.99	2.87	0.054
		Female, no carotenoid-no PQ		-9.08±3.57		
Female, lutein+PQ			-0.51±2.84			
Sex × Age	Age 9, female	1,32.85	-1.85±2.10	0.77	0.386	

Significant values are represented in bold type

**Table S2.** (continue)

Dependent variable	Source of variation	<i>d.f.</i>	Estimate±SE	<i>F</i>	<i>P</i>		
MDA (µg MDA ml <sup>-1</sup> )	Intercept		14.37±18.28				
	Treatment	β-carotene+PQ	3,24.82	-0.54±0.51	0.88	0.467	
		No carotenoid-no PQ		0.80±0.64			
		Lutein+PQ		-0.21±0.47			
	Sex	Female	1,24.86	-0.44±0.45	3.82	0.062	
	Age	9 days of age	1,34.13	-1.39±0.48	1.74	0.196	
	Hatching date		1,32.64	-5.18±8.25	0.39	0.535	
	Brood size		1,25.84	-0.28±0.17	2.63	0.117	
	MDA at hatching		1,28.11	0.86±0.86	1.00	0.326	
	Plasma lipids		1,38.51	-0.17±0.10	2.74	0.106	
	Treatment × Age	Age 9, β-carotene+PQ	3,32.94	1.11±0.56	1.92	0.146	
		Age 9, no carotenoid-no PQ		0.91±0.53			
		Age 9, lutein+PQ		1.08±0.52			
		Treatment × Sex	Female, β-carotene+PQ	3,23.54	0.29±0.57	2.66	0.071
			Female, no carotenoid-no PQ		-1.48±0.67		
			Female, lutein+PQ		-0.13±0.53		
	Sex × Age	Age 9, female	1,33.94	0.73±0.41	3.13	0.086	
	Carbonyl group (nmol ml <sup>-1</sup> )	Intercept		2.22±5.75			
		Treatment	β-carotene+PQ	3,18.349	0.22±0.17	6.31	<b>0.004</b>
No carotenoid-no PQ				0.41±0.19			
Lutein+PQ				-0.18±0.16			
Sex		Female	1,20.17	0.20±0.14	0.82	0.375	
Age		9 days of age	1,28.01	0.13±0.20	0.24	0.627	
Hatching date			1,22.46	-0.77±2.60	0.09	0.771	
Brood size			1,15.90	-0.01±0.05	0.02	0.905	
MDA at hatching			1,16.35	-0.25±0.23	1.17	0.295	
Plasma protein			1,38.73	-0.11±0.21	0.29	0.595	
Treatment × Age		Age 9, β-carotene+PQ	3,28.05	-0.18±0.23	1.15	0.346	
		Age 9, no carotenoid-no PQ		0.05±0.23			
		Age 9, lutein+PQ		0.20±0.23			
		Treatment × Sex	Female, β-carotene+PQ	3,17.46	-0.12±0.16	1.71	0.203
			Female, no carotenoid-no PQ		-0.40±0.18		
			Female, lutein+PQ		-0.07±0.15		
Sex × Age		Age 9, female	1,28.30	-0.21±0.17	1.56	0.222	
Body mass (g)		Intercept		2390.11±950.53			
		Treatment	β-carotene+PQ	3,38.78	22.33±31.24	1.20	0.322
	No carotenoid-no PQ			29.85±38.15			
	Lutein+PQ			-32.60±31.24			
	Sex	Female	1,38.39	-14.77±28.78	3.95	0.054	
	Age	9 days of age	1,31.28	-62.35±15.45	35.05	<b>&lt;0.001</b>	
	Hatching date		1,37.00	-1040.24±428.25	5.90	<b>0.020</b>	
	Brood size		1,35.11	-10.45±9.42	1.23	0.275	
	Body mass at hatching		1,35.65	1.83±1.01	3.26	0.080	
	Treatment × Age	Age 9, β-carotene+PQ	3,31.16	5.27±17.94	1.37	0.271	
		Age 9, no carotenoid-no PQ		2.17±19.05			
		Age 9, lutein+PQ		30.37±17.19			
		Treatment × Sex	Female, β-carotene+PQ	3,35.82	-62.92±30.17	1.80	0.165
			Female, no carotenoid-no PQ		-36.86±35.57		
			Female, lutein+PQ		-14.65±30.07		
	Sex × Age	Age 9, female	1,31.07	29.01±13.44	4.66	<b>0.039</b>	

Significant values are represented in bold type

**Table S2.** (continue)

Dependent variable	Source of variation	<i>d.f.</i>	Estimate±SE	<i>F</i>	<i>P</i>	
Tarsus length (mm)	Intercept		180.55±91.32			
	Treatment	β-carotene+PQ	3,37.66	0.90±2.48	0.98	0.415
		No carotenoid-no PQ		0.01±3.22		
		Lutein+PQ		-3.56±2.51		
	Sex	Female	1,36.53	-1.96±2.44	4.84	<b>0.034</b>
	Age	9 days of age	1,31.35	-4.03±0.73	111.14	<b>&lt;0.001</b>
	Hatching date		1,37.11	-77.92±41.42	3.54	0.068
	Brood size		1,35.25	-1.04±0.90	1.35	0.253
	Tarsus at hatching		1,35.85	1.27±0.45	8.15	<b>0.007</b>
	Treatment × Age	Age 9, β-carotene+PQ	3,31.22	0.05±0.85	0.77	0.521
		Age 9, no carotenoid-no PQ		0.68±0.90		
		Age 9, lutein+PQ		1.02±0.81		
	Treatment × Sex	Female, β-carotene+PQ	3,36.14	-3.23±2.90	1.05	0.383
		Female, no carotenoid-no PQ		-1.79±3.42		
		Female, lutein+PQ		1.11±2.93		
	Sex × Age	Age 9, female	1,31.14	0.74±0.63	1.35	0.254

Significant values are represented in bold type

**Table S3.** Summary of full general linear models of the effect of carotenoid supplementation on inflammatory immune response to phytohaemagglutinin (PHA) of yellow legged gull chicks after Paraquat administration (i.e. 12 days of age).

Dependent variable	Source of variation		<i>d.f.</i>	Estimate±SE	<i>F</i>	<i>P</i>
Inflammatory immune response to PHA at 12 days of life (mm)	Intercept			15.26±13.82		
	Treatment	β-carotene+PQ	3,25	0.16±0.19	1.92	0.152
		No carotenoid-no PQ		0.48±0.21		
		Lutein+PQ		0.15±0.18		
	Sex	Female	1,25	0.03±0.15	0.05	0.828
	Hatching date		1,25	-7.75±6.24	1.54	0.226
	Body mass at hatching		1,25	0.03±0.01	4.36	<b>0.047</b>
	Brood size		1,25	0.13±0.13	0.94	0.342

Significant values are represented in bold type