

Letter to the editor:

AN UPDATE ON THE POTENTIAL HEALTH BENEFITS OF CAROTENES

Jae Kwang Kim

Division of Life Sciences, College of Life Sciences and Bioengineering, Incheon National University, Incheon, 406-772, Korea; Phone: +82-32-835-8241, Fax: +82-32-835-0763, E-mail: kjpkj@inu.ac.kr

<http://dx.doi.org/10.17179/excli2015-664>

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>).

Dear Editor,

Carotenes, which are yellow-orange pigments, are a class of related organic compounds classified as hydrocarbons, more specifically as terpenoids, with the molecular formula C₄₀H₅₆. Plants, fungi, and photosynthetic bacteria synthesize carotenes, while animals must obtain them as a dietary nutrient (Vrolijk et al., 2015). Plants are capable of synthesizing several isomers of carotene. Alpha-carotene (α -carotene) and beta-carotene (β -carotene) are the two primary isomers found in plants; other carotene isomers found in plants are gamma-, delta-, epsilon-, and zeta-carotene (γ , δ , ϵ , and ζ -carotene) (Hammond and Renzi, 2013). β -Carotene is the most common form of carotene in plants and can be found in yellow, orange, and green leafy vegetables and fruits. It is an important dietary resource and a precursor of vitamin A in humans (Haskell, 2012; Tang, 2012; Sommer and Vyas, 2012).

Carotenes show a range of biological activity and health benefits for animals, making it an interesting material for the pharmaceutical, food, and cosmetics industries. We have reviewed the most recent studies on carotenes and its biological and pharmacological activities (Table 1).

Table 1: Recent studies on carotene and its biological and pharmacological activities

Key message	Reference
A treatment strategy using vitamins E and C combined with β -carotene significantly improved cognitive function in elderly subjects, particularly with higher doses of β -carotene.	Li et al., 2015
The combination of antioxidants and UV filters in sunscreens was shown to reduce cutaneous penetration of UV light and improve sunscreen safety. β -Carotene alone, and a mixture of β -carotene and trans-resveratrol, was shown to reduce the delivery of light from four different UV filters to the stratum corneum and viable epidermis.	Freitas et al., 2015
Diets high in β -carotene and α -carotene were shown to be associated with a reduced occurrence of type 2 diabetes in generally healthy men and women.	Sluijs et al., 2015
Higher nonsupplemented serum β -carotene concentrations were shown to be negatively associated with all-cause mortality among asbestos-exposed individuals.	Hashim et al., 2015

Table 1 (cont.): Recent studies on carotene and its biological and pharmacological activities

Key message	Reference
β -Carotene showed an ameliorative effect against arsenic-induced toxicity in albino mice mediated by its antioxidant and antigenotoxic properties.	Das et al., 2015
A favorable effect of β -carotene on insulin sensitivity in obese individuals that could involve a positive regulation of adiponectin, either directly or via its provitamin A activity, was shown.	Ben Amara et al., 2015
β -Carotene was shown to be capable of exerting antioxidant activity in plasma without triggering pro-oxidant events in the brain, suggesting that it may be a safer nutritional supplement with provitamin A activity.	Schnorr et al., 2014
β -Carotene supraphysiological supplementation caused no toxic effects, showed a positive response in the modulation of blood pressure, and lowered serum malondialdehyde levels.	Fiorelli et al., 2014
Long-term supplemental α -tocopherol or β -carotene had no effect on liver cancer or chronic liver disease mortality over 24 years of follow-up.	Lai et al., 2014
The antioxidant action of β -carotene was shown to provide some beneficial effects in the treatment of lead poisoning.	Kasperczyk et al., 2014
β -Carotene was shown to be a potential chemotherapeutic reagent for the treatment of neuroblastoma, this effect being mediated by the regulation of the differentiation and stemness of cancer stem cells.	Lim et al., 2014
Resveratrol was suggested to regenerate β -carotene following its sacrificial protection of unsaturated lipids from oxidative stress, modeling the synergistic effects in cell membranes by combinations of dietary antioxidants.	Wang et al., 2014
β -Carotene was shown to represent an effective chemotherapeutic agent by regulating the invasion and metastasis of neuroblastoma via HIF-1 α .	Kim et al., 2014
The radioprotective and antimutagenic activity of β -carotene was discussed, and its use by the population as a means of health protection was suggested.	Berti et al., 2014
The capacity of lycopene and β -carotene to inhibit cell proliferation, arrest the cell cycle in different phases, and increase apoptosis was shown, indicating them to be potential agents for biological interference with cancer. The effect was shown to be cell type-dependent.	Gloria et al., 2014
β -Carotene improved spermatogenesis defects in titanium oxide nanoparticle-treated mice. β -Carotene showed a potent protective effect against testicular toxicity, and was suggested to be clinically useful.	Orazizadeh et al., 2014
β -Carotene exerted antikeratopathy effects and ameliorated the corneal changes in diabetic rats via its hypoglycemic and antioxidant mechanisms.	Abdul-Hamid and Moustafa, 2014
β -Carotene supplementation in weanling mice was shown to be effective in enhancing mucosal IgA induction in the jejunum or ileum. The effects were shown to be mainly due to the rheumatoid arthritis-mediated immune response.	Nishida et al., 2014
A diet containing natural carotenoids, rich in 9-cis- β -carotene, was shown to have the potential to inhibit atherosclerosis progression, particularly in a high-fat diet regime.	Harari et al., 2013
β -Carotene and vitamin E in doses higher than the recommended daily allowance were shown to significantly increase mortality.	Bjelakovic et al., 2013
β -Carotene was shown to be a potential chemotherapeutic reagent for the treatment of neuroblastoma cancer stem-like cells. The results suggested that the targeting of cancer stem cells is a novel mechanism of β -carotene.	Lee et al., 2013
β -Carotene was shown to effectively protect against nicotine-induced teratogenesis in mouse embryos through its antioxidative, antiapoptotic, and anti-inflammatory activities.	Lin et al., 2013

Table 1 (cont.): Recent studies on carotene and its biological and pharmacological activities

Key message	Reference
Treatment with 9-cis- β -carotene significantly increased retinal function in patients with retinitis pigmentosa (RP) under the tested conditions, and may represent a new therapeutic approach for some patients with RP.	Rotenstreich et al., 2013
β -Carotene was shown to decrease cholesterol absorption in the intestine and increase cholesterol excretion into the feces without a direct effect on the expression of cholesterol metabolism genes.	Silva et al., 2013
β -Carotene was shown to affect the microenvironment of a tumor, thus providing further evidence for its anticancer effects.	Lim et al., 2013
β -Carotene supplementation was shown to prevent ethanol-induced liver damage by decreasing ethanol-induced oxidative stress and inhibiting apoptosis in the liver.	Peng et al., 2013

Acknowledgements

This work was supported by the Incheon National University Research Grant in 2013.

REFERENCES

- Abdul-Hamid M, Moustafa N. Amelioration of alloxan-induced diabetic keratopathy by beta-carotene. *Exp Toxicol Pathol.* 2014;66:49-59.
- Ben Amara N, Tourniaire F, Maraninchi M, Attia N, Amiot-Carlin MJ, Raccach D, et al. Independent positive association of plasma β -carotene concentrations with adiponectin among non-diabetic obese subjects. *Eur J Nutr.* 2015;54:447-54.
- Berti AP, Düsman E, Mariucci RG, Lopes NB, Vicentini VE. Antimutagenic and radioprotective activities of beta-carotene against the biological effects of iodine-131 radiopharmaceutical in Wistar rats. *Genet Mol Res.* 2014;13:2248-58.
- Bjelakovic G, Nikolova D, Gluud C. Meta-regression analyses, meta-analyses, and trial sequential analyses of the effects of supplementation with beta-carotene, vitamin A, and vitamin E singly or in different combinations on all-cause mortality: do we have evidence for lack of harm? *PLoS One.* 2013;8:e74558.
- Das R, Das A, Roy A, Kumari U, Bhattacharya S, Haldar PK. β -carotene ameliorates arsenic-induced toxicity in albino mice. *Biol Trace Elem Res.* 2015; 164:226-33.
- Fiorelli SK, Vianna LM, Oliveira CA, Fiorelli RK, Barros BC, Almeida CR. The effects of supraphysiological supplementation of β -carotene in spontaneously hypertensive rats (SHR and SHR-sp). *Rev Col Bras Cir.* 2014;41:351-5.
- Freitas JV, Praça FS, Bentley MV, Gaspar LR. Trans-resveratrol and beta-carotene from sunscreens penetrate viable skin layers and reduce cutaneous penetration of UV-filters. *Int J Pharm.* 2015;484:131-7.
- Gloria NF, Soares N, Brand C, Oliveira FL, Borojevic R, Teodoro AJ. Lycopene and beta-carotene induce cell-cycle arrest and apoptosis in human breast cancer cell lines. *Anticancer Res.* 2014;34:1377-86.
- Hammond BR Jr, Renzi LM. Carotenoids. *Adv Nutr.* 2013;4:474-6.
- Harari A, Abecassis R, Relevi N, Levi Z, Ben-Amotz A, Kamari Y, et al. Prevention of atherosclerosis progression by 9-cis- β -carotene rich alga *Dunaliella* in apoE-deficient mice. *Biomed Res Int.* 2013;2013: 169517.
- Hashim D, Gaughan D, Boffetta P, Lucchini RG. Baseline serum β -carotene concentration and mortality among long-term asbestos-exposed insulators. *Cancer Epidemiol Biomarkers Prev.* 2015;24:555-60.
- Haskell MJ. The challenge to reach nutritional adequacy for vitamin A: β -carotene bioavailability and conversion--evidence in humans. *Am J Clin Nutr.* 2012;96:1193S-203S.
- Kasperczyk S, Dobrakowski M, Kasperczyk J, Romuk E, Prokopowicz A, Birkner E. The influence of beta-carotene on homocysteine level and oxidative stress in lead-exposed workers. *Med Pr.* 2014;65:309-16.

- Kim YS, Lee HA, Lim JY, Kim Y, Jung CH, Yoo SH, et al. β -Carotene inhibits neuroblastoma cell invasion and metastasis in vitro and in vivo by decreasing level of hypoxia-inducible factor-1 α . *J Nutr Biochem*. 2014;25:655-64.
- Lai GY, Weinstein SJ, Taylor PR, McGlynn KA, Virtamo J, Gail MH, et al. Effects of α -tocopherol and β -carotene supplementation on liver cancer incidence and chronic liver disease mortality in the ATBC study. *Br J Cancer*. 2014;111:2220-3.
- Lee HA, Park S, Kim Y. Effect of β -carotene on cancer cell stemness and differentiation in SK-N-BE(2)C neuroblastoma cells. *Oncol Rep*. 2013;30:1869-77.
- Li Y, Liu S, Man Y, Li N, Zhou YU. Effects of vitamins E and C combined with β -carotene on cognitive function in the elderly. *Exp Ther Med*. 2015;9:1489-93.
- Lim JY, Kim YS, Kim Y. β -carotene regulates the murine liver microenvironment of a metastatic neuroblastoma. *J Cancer Prev*. 2013;18:337-45.
- Lim JY, Kim YS, Kim KM, Min SJ, Kim Y. β -carotene inhibits neuroblastoma tumorigenesis by regulating cell differentiation and cancer cell stemness. *Biochem Biophys Res Commun*. 2014;450:1475-80.
- Lin C, Yon JM, Jung AY, Lee JG, Jung KY, Lee BJ, et al. Antiteratogenic effects of β -carotene in cultured mouse embryos exposed to nicotine. *Evid Based Complement Alternat Med*. 2013;2013:575287.
- Nishida K, Sugimoto M, Ikeda S, Kume S. Effects of supplemental β -carotene on mucosal IgA induction in the jejunum and ileum of mice after weaning. *Br J Nutr*. 2014;111:247-53.
- Orazizadeh M, Khorsandi L, Absalan F, Hashemitarbar M, Daneshi E. Effect of beta-carotene on titanium oxide nanoparticles-induced testicular toxicity in mice. *J Assist Reprod Genet*. 2014;31:561-8.
- Peng HC, Chen YL, Yang SY, Ho PY, Yang SS, Hu JT, et al. The antiapoptotic effects of different doses of β -carotene in chronic ethanol-fed rats. *Hepatobiliary Surg Nutr*. 2013;2:132-41.
- Rotenstreich Y, Belkin M, Sadetzki S, Chetrit A, Ferman-Attar G, Sher I, et al. Treatment with 9-cis β -carotene-rich powder in patients with retinitis pigmentosa: a randomized crossover trial. *JAMA Ophthalmol*. 2013;131:985-92.
- Schnorr CE, Morrone Mda S, Simões-Pires A, Bittencourt Lda S, Zeidán-Chuliá F, Moreira JC. Supplementation of adult rats with moderate amounts of β -carotene modulates the redox status in plasma without exerting pro-oxidant effects in the brain: a safer alternative to food fortification with vitamin A? *Nutrients*. 2014;6:5572-82.
- Silva LS, de Miranda AM, de Brito Magalhães CL, Dos Santos RC, Pedrosa ML, Silva ME. Diet supplementation with beta-carotene improves the serum lipid profile in rats fed a cholesterol-enriched diet. *J Physiol Biochem*. 2013;69:811-20.
- Sluijs I, Cadier E, Beulens JW, van der A DL, Spijkerman AM, vander Schouw YT. Dietary intake of carotenoids and risk of type 2 diabetes. *Nutr Metab Cardiovasc Dis*. 2015;25:376-81.
- Sommer A, Vyas KS. A global clinical view on vitamin A and carotenoids. *Am J Clin Nutr*. 2012;96:1204S-6S.
- Tang G. Techniques for measuring vitamin A activity from β -carotene. *Am J Clin Nutr*. 2012;96:1185S-8S.
- Vrolijk MF, Opperhuizen A, Jansen EH, Godschalk RW, Van Schooten FJ, Bast A, et al. The shifting perception on antioxidants: The case of vitamin E and β -carotene. *Redox Biol*. 2015;4C:272-8.
- Wang HJ, Liang R, Fu LM, Han RM, Zhang JP, Skibsted LH. Nutritional aspects of β -carotene and resveratrol antioxidant synergism in giant unilamellar vesicles. *Food Funct*. 2014;5:1573-8.