

## DIETITIANS' NEWS

### Metabolic Engineering of Flax Increases Its Carotenoid Content 8- to 19- Fold

By Diane H. Morris

Flax contains two carotenoids – lutein and zeaxanthin – but it does not naturally contain other carotenoids such as  $\alpha$ -carotene and  $\beta$ -carotene. The carotenoids are pigments responsible for the yellow to red colour of some fruit and vegetables. They act as antioxidants and may help reduce the risk of cardiovascular disease.<sup>1</sup>

Carotenoids with vitamin A activity, such as  $\alpha$ -carotene and  $\beta$ -carotene, participate in vision, growth, reproduction and immune function; they can be converted into retinol, a form of vitamin A. Lutein and zeaxanthin are not considered to have vitamin A activity because they are not converted to retinol.

However, lutein and zeaxanthin are the only carotenoids that concentrate abundantly in the eye, particularly in the inner layer of the retina (the macula).<sup>2</sup> Lutein and zeaxanthin, along with other carotenoids, have the potential to help protect against eye diseases such as age-related macular degeneration (AMD) by decreasing oxidative stress in the eye and filtering harmful blue light. AMD is the third cause of visual impairment in industrialized countries, and nearly 9% of people with AMD become blind.<sup>3</sup> Clinical studies suggest that people with AMD have lower concentrations of lutein and zeaxanthin in the macula than people without AMD.<sup>2</sup>

Researchers Masaki Fujisawa and colleagues in Japan metabolically engineered flax to increase the carotenoid content of its seed oil.<sup>4</sup> The methodology involved inserting into flax seed plants a gene that encodes an enzyme. The enzyme converts starter compounds into phytoene, which is the precursor of  $\alpha$ -carotene,  $\beta$ -carotene, lutein and zeaxanthin.

The researchers reported that transgenic flax plants produced seeds with a lutein concentration of between 1.5- and 3-fold higher than regular flax seeds. Furthermore, significant amounts of  $\alpha$ -carotene and  $\beta$ -carotene – two carotenoids not normally found in flax – were produced, thus increasing the total carotenoid content of the transgenic flax seeds 8- to 19-fold. Transgenic flax plants grown in the greenhouse were not different in form or structure from untreated plants, except that seeds derived from transformed plants were more orange than yellow, due to their extra carotenoids.

These findings have practical applications for an aging population at risk of AMD. Traditional milled flax contains about 46  $\mu\text{g}$  of carotenoids (lutein + zeaxanthin) per tbsp.<sup>5</sup> Based on data presented in Fujisawa's study,<sup>4</sup> transgenic flax seeds contained an average of 750  $\mu\text{g}$  of total carotenoids (lutein +  $\alpha$ -carotene +  $\beta$ -carotene) per tbsp. For people at risk of AMD, eating carotenoid-enriched flax would increase carotenoid intake and may help improve eye health. Eating a little traditional flax every day may help as well.

## References

- <sup>1</sup>Voutilainen S, Nurmi T, Mursu J, Rissanen TH. 2006. Carotenoids and cardiovascular health. *Am J Clin Nutr.* 83:1265-1271.
- <sup>2</sup>Mares JA, LaRowe TL, Snodderly DM, et al. 2006. Predictors of optical density of lutein and zeaxanthin in retinas of older women in the Carotenoids in Age-Related Eye Disease Study, an ancillary study of the Women's Health Initiative. *Am J Clin Nutr.* 84:1107-1122.
- <sup>3</sup>World Health Organization. Priority eye diseases. [cited 17 September 2008]. Available from: <http://www.who.int/blindness/causes/priority/en/print.html>
- <sup>4</sup>Fujisawa M, Watanabe M, Choi S-K, et al. 2008. Enrichment of carotenoids in flaxseed (*Linum usitatissimum*) by metabolic engineering with introduction of bacterial phytoene synthase gene *crtB*. *J Biosci Bioeng.* 105:636-641.
- <sup>5</sup>Nutrient Data Laboratory, Beltsville Human Nutrition Research Center, Agriculture Research Service. USDA's National Nutrient Database for Standard Reference, Release 21. [cited 19 September 2008]. Available from: <http://www.ars.usda.gov/nutrientdata>