Carrots With Character

Shredded in salads and slaws, steamed, or just peeled and dunked in an herb-speckled dip, carrots are versatile veggies that add colorful zest to our dinner plates. These crunchy orange roots are also a well-known source of vitamin A. Just a single, full-size carrot more than fulfills an adult's daily quotient of the essential vitamin.

But the carrot hasn't always been the vitamin A powerhouse that it is today. Over two decades ago, scientists in the ARS Vegetable Crops Research Unit at Madison, Wisconsin, began a quest to breed carrots packed with beta-carotene—an orange pigment used by the body to create vitamin A. Thanks largely to this ARS work, today's carrots provide consumers with 75 percent more beta-carotene than those available 25 years ago.

The researchers, led by plant geneticist Philipp Simon, haven't limited themselves to the color orange. They've selectively bred a rainbow of carrots—purple, red, yellow, even white. Scientists are learning that these plant pigments perform a range of protective duties in the human body—which is not surprising, says Simon, since many of the pigments serve to shield plant cells during photosynthesis.

Red carrots derive their color mainly from lycopene, a type of carotene believed to guard against heart disease and some cancers. Yellow carrots accumulate xanthophylls, pigments similar to beta-carotene that support good eye health. Purple carrots possess an entirely different class of pigments—anthocyanins—which act as powerful antioxidants.

While colored carrots are unusual, they're not exactly new. "Purple and yellow carrots were eaten more than 1,000 years ago in Afghanistan and 700 years ago in western Europe," says Simon. "But the carrot-breeding process has gone on intensively for just 50 years."

Simon and his team of ARS researchers and colleagues at the University of Wisconsin-Madison (UW) have recently shown that their highly pigmented carrots are a ready source of some sought-after nutrients.

The Eyes Have It

Lutein is one of the hydroxy carotenoids that make up the macular pigment of human retinas. Consuming foods high in lutein may increase the density of this pigment and decrease the risk for developing macular degeneration, an age-related disease.

"Up to now," says Simon, "we didn't know whether lutein was biologically available from carrots, because they're considered a complex food."

In a study to determine humans' lutein uptake from lutein-rich yellow carrots, Simon, along with UW's Sherry Tanumihardjo, recruited nine 23- to 28-year-old volunteers to eat the carrots and take a lutein supplement. By reading the participants' blood serum levels, the researchers found that lutein from the carrots was 65 percent as bioavailable as it was from the supplement.

Tanumihardjo, an assistant professor in UW's Department of Nutritional Sciences, says, "While other foods might contain higher levels of lutein—like spinach for instance—lutein is absorbed very well from lutein-rich carrots."

In another study, Simon and Tanumihardjo found that lycopene from red-pigmented carrots is 40 percent as bioavailable as it is from tomato paste. "Not everyone eats or likes tomatoes," she says, "so finding another source of lycopene that also provides beta-carotene is very positive."

Their lycopene study appeared in the May 2004 issue of the *European Journal of Clinical Nutrition.* The lutein study appeared in the July 2004 issue of the *American Journal of Clinical Nutrition.*

STEPHEN AUSMUS (K11611-1)

ARS researchers have selectively bred carrots with pigments that reflect almost all colors of the rainbow. More importantly, though, they're very good for your health.

STEPHEN AUSMUS (K11611-2)

Cross-sections of the highly pigmented carrots.

Behind the Colors

In nature, different strains of carrots contain varying types and amounts of carotenoids—the pigments responsible for orange, yellow, and red colors. To assist seed companies and growers who wish to produce nutrient-rich carrots, Simon and his lab are working to map all the genes that play a part in synthesizing carotenoids in major carrot lines. Simon now knows of 20 genes that are involved. But determining a particular gene's role in generating carotenoids is not that straightforward.

"There are complexities in reading these genes," he says, "since their functions often change with the plant as it progresses through its life cycle." From Simon's work, it appears that two or three major genes account for differences in white and orange carrots and that another couple of genes separate yellow carrots from red.

Why Be Conventional?

What would you say to a glass of purple carrot juice? Some aren't so sure.

Aside from enhancing the nutritional value of carrots—as well as onions, garlic, and cucumbers—researchers at Simon's laboratory also work to improve the veggies' culinary quality and appeal.

"It's hard to know what to aim for when selecting for a purple carrot," Simon says, "since we've no defined type to go by." So he's subjecting the new varieties to consumer taste tests, hoping to find carrots with a sweet and mild flavor.

"People who are asked to taste the colorful carrots are concerned about their flavor," says Simon. "We've become married to the colors we associate with particular foods. We eat with our eyes, to some extent."

Tanumihardjo agrees. "I did a study to find out whether carrot color prompted perception of taste at all," she says. "When people were able to see the color of the carrot—whether it was purple or red—they responded more favorably to it."

With the help of Tanumihardjo, Simon is tapping taste preferences through an unexpected group of eaters: children in Wisconsin's inner cities and American Indian reservations. Children from lower income groups are at greater risk for developing a nutritional deficiency, like low vitamin A status. "Some of these kids have never even had a carrot before," says Simon. But their comments so far have been positive, according to Tanumihardjo.

With their compelling health benefits and a thumbs-up from taste testers, Simon's colorful carrots will be a great addition to supermarket produce aisles once consumers create a demand for them.—By **Erin Peabody,** ARS.

This research is part of Plant, Microbial, and Insect Genetic Resistance, Genomics, and Genetic Improvement, an ARS National Program (#301) described on the World Wide Web at www.nps.ars.usda.gov.

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