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Rings shown on the plastic plate examined by ARS chemist Betty Burri reveal the amount of a vitamin-A-related protein in blood samples from volunteers. (K5755-3)

What Carotenes Do for You

Carotenes—members of the family of orange, yellow, and red pigments—may be essential nutrients that we require for the best health, two preliminary ARS studies suggest.

"Right now, carotenes aren't among the list of 23 vitamins and minerals that are known to be essential," says Betty J. Burri, a chemist at the ARS Western Human Nutrition Research Center in San Francisco, California.

Neither are the many other carotenoids that make carrots a vivid orange, turn squashes a colorful yellow, or tint tomatoes an attractive red.

"It might come as a surprise to most people," says Burri, "that even beta carotene, perhaps the best known of the carotenes, doesn't have its own RDA, or Recommended Dietary Allowance. The only proven function for carotenes is as precursors—called provitamins—to vitamin A."

To find more about the interrelation of carotenes and vitamin A, Burri conducted two experiments, each with about a dozen healthy women aged 18 to 42. She designed the tests to explore the question, "If people eat adequate amounts of vitamin A, do they need to eat carotenes?"

She explains, "If the only acknowledged role of carotenes is to serve as precursors of vitamin A, then, in theory at least, if you have enough vitamin A, you don't need the carotenes."

Our bodies require vitamin A for good eyesight, proper growth and reproduction, and prevention of some diseases.

Burri and coworkers are now publishing results of the second study, completed in l994. Many of the findings agree with those of the first experiment, which ended in 1992. Today, both experiments stand as the longest and most rigidly controlled beta carotene studies done with human volunteers.

Burri's volunteers lived at the nutrition center for 14 to 17 weeks, so scientists and other staffers could control all food and exercise.

Both studies tracked many key indicators of general health. In each experiment, volunteers ate meals that featured familiar foods—but were low in carotenes and other carotenoids. In one test, all volunteers ate only meals low in beta carotene. They followed this stint with a repletion phase in which they downed beta carotene supplements in addition to low-carotene meals.

In the other test, all volunteers ate low-carotene meals. Some took carotene supplements throughout the study; the others added supplements only during the repletion phase.

Importantly, all meals provided an ample supply of preformed vitamin A from such sources as beef, chicken, turkey, pork, and fish. One day's menu, for example, included bagels, cream cheese, and low-fat milk at breakfast; pork chow mein, apple juice, and macaroon cookies for lunch; and beef-potato casserole, pasta salad, and grape juice for dinner, with vanilla ice cream as a snack before bedtime. Meals excluded all colorful fruits and veggies.

The low-carotene stints may have been the culprit behind two kinds of symptoms noted in some volunteers in both studies: changes in the level of thyroid hormones and an increase in oxidative damage. Too, the low-carotene regimen may have been a contributing factor to disrupted menstrual cycles.

Burri says she and colleague Zisca R. Dixon checked levels of thyroid hormones because the linkages between vitamin A and thyroid hormones are well established. "But links are less well-established," Burri explains, "between thyroid hormones and carotenoids. Our results suggest that low-carotene regimens may stimulate increases in a key thyroid hormone, thyroxine."

Some—but not all—carotenes can protect the body from oxygen damage. "Oxidation," Burri says, "leads to the release of rogue electrons, called free radicals, that have been implicated in increased incidence of cancer, stroke, arteriosclerosis, and cataracts. Many carotenes act as antioxidants in lab tests, but more evidence is needed on how important they are to human health."

The researchers found that several indicators of oxidative damage were higher during depletion than repletion. Concentrations of compounds in the breath and blood known as carbonyls, for instance, were about 50 percent higher during the low-carotene phases. An indicator of oxidative damage called thiobarbituric acid reactive substances—or TBARS—increased in plasma during depletion by about four times. And the activity of superoxide dismutase, a well-known antioxidant, decreased by about 30 percent during depletion.

In both tests, most of the women also developed abnormal menstrual cycles. However, most participants reported normal cycles within 3 months after leaving the center.

Physiologist Mary J. Kretsch at the center led this part of the studies and a series of four shorter tests that tracked effects of low-carotenoid meals on menstrual cycles of 35 healthy women.

She says her findings suggest that regimens low in carotenes and other carotenoids may cause menstrual cycle dysfunction. Further, supplementing the women with 95 retinol equivalents a day of beta carotene—about the same amount as in 2/3 cup green beans—wasn't enough to ensure normal ovulatory function.

"Perhaps a higher amount of beta carotene," she says, "is required to prevent these menstrual cycle abnormalities. Or, other carotenoids or other compounds found in highly pigmented fruits and vegetables might be needed."

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For studies to determine the importance of carotene, certified nursing assistant Rowena Mallari (left) samples a low-carotene lunch served by dietitian Doris DeLeon. Colorful, high-carotene foods are in the foreground. (K5758-1)

Results from the carotene studies, says Burri, "suggest that we need carotenes—at least in small amounts—not only as vitamin A precursors but also as antioxidants.

"There's some evidence from epidemiological studies that carotenes may have important functions beyond serving as vitamin A precursors, particularly as protectors against oxidative damage. If carotenes turn out to be important to human nutrition in their own right, their ability to defend the body against oxidative damage will likely be the most convincing factor.

"For now," Burri says, "we have important new facts about carotenes from our studies, but we still don't know what amount of carotenes is needed for optimum health. Nor do we know which carotenes are best for us. However, if our findings hold up in future studies at our lab and elsewhere, we will have established that carotenes are required for optimal human health.

"Meanwhile, the experiments are a reminder of how important it is to eat vegetables—even some of the less popular ones—that are good sources of carotenes."

Those veggies include carrots, sweetpotatoes, spinach, collards, parsley, kale, pumpkin, mustard greens, beet greens, and winter squash. Several fruits are also good sources, such as apricots, canteloupe, and mangoes.

In addition to ARS colleagues at San Francisco and the Beltsville (Maryland) Human Nutrition Research Center, Burri collaborated with researchers from the University of California at Davis and Los Angeles, University of Illinois at Champaign-Urbana, Centers for Disease Control and Prevention, University of Nevada at Reno, University of Connecticut, and Florida International University.—By **Marcia Wood,** ARS.

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