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Roy Constantin (right), director of Louisiana State University's Hammond Research Station, and Ray Shelton, a station employee, pick Chandler strawberries being grown for ellagic acid and other studies.

Boosting Ellagic Acid in Strawberries

Strawberries have long been associated with good health.

Of course, until recently no one knew that eight medium-size berries contained only 30 calories and had absolutely no saturated fat, cholesterol, or sodium—or that they were high in folate, overflowing with vitamin C, a good amount of dietary fiber and potassium, and traces of calcium and iron.

Until this century, it was not known that strawberries contain ellagic acid—a natural organic compound that some studies have shown to have a beneficial health effect. [See "Building a Better Strawberry," *Agricultural Research*, September, 1991, pp. 24-25.]

ARS scientists at Beltsville, Maryland, and Poplarville, Mississippi, are studying the genetics of different strawberry varieties, hoping to breed more ellagic acid as well as other beneficial nutrients into the fruit.

"We don't know how ellagic acid is inherited, but for several years we've been studying strawberry fruit and all parts of the plant to determine where the highest amounts of the acid accumulate," says John L. Maas. A plant pathologist with the ARS Fruit Laboratory in Beltsville, Maas and colleagues Gene J. Galletta and Shiow Y. Wang have evaluated 36 strawberry varieties for ellagic acid content.

"Interestingly, we found the highest amounts of ellagic acid in strawberry plant leaves," Maas reports. "Leaves of Tribute and Delite, two varieties introduced by ARS, showed more of the compound than any others tested. Seeds, in general, showed more ellagic acid than fruit pulp, and pulp from green strawberries contained more than pulp from red, ripe fruit."

Although the manner of inheritance of ellagic acid is not known, this study showed that the amount of the compound varies significantly by strawberry variety.

"This means that we now know we can breed for high ellagic acid content in fruit, where it is most needed," Maas explains.

According to Gary D. Stoner, who is with the Department of Preventive Medicine at Ohio State University in Columbus, the beneficial health effects of ellagic acid have not been adequately determined. So he and colleagues tested the compound in its pure form for anticarcinogenic and antimutagenic effects. In pure form, ellagic acid is highly insoluble and biologically unavailable.

Strawberries contain ellagic acid—a natural organic compound that some studies have shown to have a beneficial health effect.

However, Maas says that ellagic acid, as it is biosynthesized in plants, occurs in combination with glucose as ellagitannins. These compounds are quite water soluble and biologically available.

"This means that relatively small amounts of ellagitannins may be more effective in the human diet than large doses of ellagic acid," Maas reports. "Strawberry fruit produce at least five ellagitannins, but their chemical structures and their effectiveness as anticarcinogens have yet to be determined.

"Dr. Stoner just completed a study to test the effectiveness of natural ellagitannins from dehydrated strawberry fruit added to diets of rats to protect against some forms of cancer, especially esophageal," says Maas. "The diet significantly reduced the incidence of chemically induced tumors in the esophagus. Stoner and colleagues believe that in addition to ellagic acid, other compounds in the fruit contributed to the positive results."

In a collaborative study with the National Cancer Institute, Stoner and colleagues found ellagic acid in raspberries, blackberries, cranberries, walnuts, and pecans.

"Although we don't yet know how much ellagic acid would need to be consumed to produce beneficial results, these studies indicate that a diet containing these foods would certainly be recommended," says Stoner.

Upping the Berries' Quotient

Now that it is known that ellagic acid does exist in strawberry fruit, seeds, and leaves, other ARS scientists are seeking ways to increase the amounts.

At the Small Fruits Research Station in Poplarville, plant pathologist Barbara J. Smith and horticulturist James B. Magee are looking at the effect nitrogen may have on ellagic acid in two strawberry varieties. And in collaboration with Roy J. Constantin, Director of Louisiana State University's Hammond Research Station, they're adding several types of soil amendments to strawberry plots to study their possible effect on ellagic acid content.

In a greenhouse study, Smith and Magee fertilized potted Chandler and Pelican strawberry plants with nitrogen-rich ammonium nitrate,

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Plant geneticist Gene Galletta and plant pathologist Barbara Smith evaluate Chandler strawberries for growth and ripening characteristics.

urea, calcium nitrate, and ammonium sulfate. The control plants received no nitrogen.

"We found no difference in ellagic acid content of ripe fruit harvested from plants grown in all sources of nitrogen. However, we did find differences between strawberry plant varieties: Chandler produced about twice as much as Pelican," Magee reports. "We're still analyzing data for more details."

In the Hammond study, Magee and Constantin have been adding several amendments to the soil. Initially, they applied one of the following to each strawberry test plot at the rate of 10 tons per acre: hardwood bark, cottonwood bark, crab meal, sewage sludge, and waste generated from processing cottonseed.

"Our soil is very low in organic matter, and we're hoping to increase the levels with these additives," Constantin says. A study completed with these same amendments last year showed no significant changes in strawberry yield.

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Pelican, one of the two strawberry varieties used in the Poplarville ellagic acid studies, was developed and released by Gene J. Galletta and colleagues. Galletta is a plant geneticist at the ARS Fruit Laboratory in Beltsville.

Now winding down his career, Galletta plans to retire from ARS in January 1998. He has developed and released 21 strawberry varieties for growers and 4 disease-resistant strawberries for breeders. In addition, he has released 21 new blueberries, 3 thornless blackberries, and a raspberry.

Galletta introduced five new strawberry varieties in 1994 and 1995: Delmarvel, Latestar, Mohawk, Northeaster, and Primetime. Pelican and Winona are his newest introductions, released in 1996.

Pelican, resistant to anthracnose, a major strawberry disease, was developed in conjunction with researchers from the Louisiana Agricultural Experiment Station, North Carolina Agricultural Research Service, and ARS' Small Fruits Research Station at Poplarville, Mississippi.

"Pelican is best adapted to the southern Coastal Plain and lower Piedmont, especially for fall planting and late winter and early spring production," Galletta says.

Researchers at the University of Minnesota worked with Galletta for 15 years to produce a strawberry specifically adapted to the environment of the north-central region of the United States.

"We needed a variety that would fit into an integrated pest management program that included minimal use of chemicals to control pests and diseases," Galletta says. "And we needed winter-hardy plants that could resist most pathogens."

Winona, released in 1996, is the fruit of their labor. The result of cross-breeding that included Earliglow and Lateglow, two of USDA's earlier releases, Winona has consistently produced large, bountiful fruit in Minnesota field tests.

Researchers have applied for a patent for Winona, which is now available in nurseries.

"My collaborators think Winona may replace Blomidon, a strawberry variety that was popular in Minnesota before it showed symptoms of the physiological disorder June Yellows," says Galletta.—By **Doris Stanley,** ARS.

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