Antioxidants in the North

While most of the berries picked in Alaska this summer went directly to the table, freezer, or into the jelly jar, some were set aside for science. They were collected for research on the antioxidant properties of wild and domesticated berries and vegetable crops in Alaska. Researchers Roseann Leiner, Rudy Candler, and Pat Holloway are conducting the study over a span of several years.

Antioxidants are chemicals that protect key cell components by neutralizing the damaging effects of free radicals, which are natural byproducts of cell metabolism. In chemical terms, free radicals are oxygen metabolites that have an uneven number of electrons. These reactive molecules seek to form new chemical bonds with other molecules, including DNA, RNA, proteins, and lipids (Prior and Cao 2000). As free radicals travel through cells, they disrupt the structure of other molecules. Antioxidant compounds can function as alternative targets for free radicals and prevent this disruption. The presence of more free radicals than antioxidants can cause cell damage that is linked to age-related diseases such as cancers. The presence of more antioxidants than free radicals can confer health benefits.

Using modern analytical instruments, the AFES study aims to identify antioxidant compounds in such Alaska plants as wild blueberries, lingonberries, and rosehips; cultivated strawberries, red and black currants, and raspberries; and cabbage, lettuce, mustard greens, and carrots. The project involves field cultivation at the AFES Fairbanks and Palmer farms, collection of wild berries throughout the state, and analysis at the Palmer Research Center laboratory.

Among compounds having antioxidant activity are vitamins C and E, and numerous members of the flavonoid family. Some previous studies have measured levels of specific flavonoids in plants, but since many compounds contribute to a plant's antioxidant capacity, another approach has been to measure the total antioxidant activity by determining oxygen radical absorbance capacity (ORAC) (Prior and others 1998, Wang and others 1997). A 1996 study by Wang and others reported that strawberries had the highest ORAC activity of twelve fruits tested. Cao and others (1996) reported that garlic had the highest ORAC activity of twenty-two vegetables tested, and that the activities of green and black teas was higher than any vegetable.

Recent studies of antioxidants in fruits and vegetables uses high-performance liquid chromatography (HPLC) to identify and quantify the electroactive compounds in food extracts (Guo and others 1997, Adamson and others 1999). Chromatography is a technique used to separate molecules based on how they adhere to or dissolve in various solids, liquids, and gases. HPLC is used for separating, identifying, purifying, and quantifying various compounds. For the AFES study, known antioxidant compounds were purchased and used for method development in 2001 and 2002. In the

Blueberry.
—Photo by Scott Bauer, USDA ARS, www.forestryimages.org

summer of 2002, numerous berry and leaf greens samples were collected and frozen until they could be extracted and analyzed. In early 2003, many of these were processed on the HPLC. Analyses on the HPLC of previously collected samples is ongoing.

The AFES study will expand knowledge of human nutritional and antioxidant components of Alaska fruits and vegetables. Results could be used as a marketing tool to promote Alaska grown and harvested products. For example, if Alaska wild blueberries and lingonberries are highly antioxidant, opportunities in domestication and marketing of these as health food specialty products could increase. This project also will expand the capabilities of the Palmer Research Laboratory to provide local analysis of perishable samples whose chemistry may change in transit to more remote laboratories. The research is funded by a USDA special grant.

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Shapeshifter CARBON: a universal building block

Doreen Fitzgerald

Artificial heart valves, oil drills, soda pop, and roses share a common characteristic: each of them employs some form of the versatile element carbon (symbol C, atomic number 6, from the Latin word for charcoal, *carbo*).

As a simple element, carbon occurs as graphite, diamond, and fullerene. Pyrolytic carbon, which has a disordered graphite structure, is used in heart valves. Diamond, a crystallized form of pure carbon and the world's hardest natural substance, is widely employed in drilling and cutting tools. Carbonated beverages get their fizz from an infusion of carbon dioxide, a major performer in the carbon cycle and of current interest in climate warming because it functions in the atmosphere as a greenhouse gas. All living organisms, like the rose plant, contain carbon, which provides the framework for tissues, the elements of which are grouped around chains or rings made of carbon atoms. The human body is about eighteen percent carbon by weight.

Although carbon is not the most abundant element on Earth, the reactivity of the carbon atom allows it to link with other carbon atoms and other elements. It is known to form millions of compounds, more than the number formed by all the other elements combined. Several research projects at the school of Natural Resources and Agricultural Sciences are looking at the behavior of carbon compounds in northern ecosystems. Before discussing them, this article will look at some of the basic characteristics of carbon and the carbon cycle.

Diamond and graphite are deposited in widely scattered locations around the Earth. In 1985, fullerenes, clusters of carbon atoms, were discovered in a research laboratory among the byproducts of laser-vaporized graphite. Because their hollow spherical structure is similar to Buckminster Fuller's geodesic domes, they're called "buckyballs," as well as "fullerenes." Their unique structure, heat resistance, and electrical conductivity point to such possible uses as high-temperature lubricants, microfilters, more efficient semiconductors, and for manufacturing processes. Fullerenes also have been found in natural rock.

A diamond, no matter what the size, may be considered a single molecule of carbon atoms, each joined to four other carbons in regular tetrahedrons, or triangular prisms. Graphite consists of layers of carbon atoms joined in regular hexagons by strong bonds. The layers are held together by long-range, relatively weak attractive forces. The layers easily can slide over each other, which in part explains the lubricating property of graphite. Amorphous carbon is a form of graphite. It consists of microscopic crystals obtained by heating a carbon-rich material to 1,200–1,800°F in a limited amount of air so that incomplete combustion occurs. By this means coke is produced from coal, carbon black (lampblack or channel black) from natural gas or petroleum, charcoal from wood, bone char from bone and, from petroleum coke or coal, baked carbon, carbon arcs, or carbon electrodes.

The electrons in the outer shell of atoms can interact with each other to form chemical bonds. The exact nature of these bonding interactions mainly depends on the electronegativities of the individual atoms. Bonds between atoms with large differences in electronegativity tend to be ionic: the electrons are fully donated from one atom to another. Bonds between atoms with identical, or small differences in electronegativity tend to be covalent: the electrons are shared between the two atomic centers.

Because a carbon atom has four valence electrons and makes covalent bonds, it can form molecules that are long chains, such as hydrocarbons, carbohydrates, lipids, proteins,

"Buckyball," or fullerene, one of the natural molecular structures of carbon. This structure is similar to Buckminster Fuller's famous geodesic domes.