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Devising Healthier Foods

Enhancing the good components and removing the unhealthy ones may prevent disease

Rachel Petkewich

LEONARD M. PIKE set out to kick up some school spirit and ended up boosting the nutritional content of a carrot. As a member of Texas A&M University's faculty, now professor emeritus of horticulture, Pike knew the pride that surrounded maroon, one of the school's colors. He thought cultivating a maroon carrot would be fun for the Texas Aggies. But in the process of breeding a vegetable with novel aesthetics, the focus changed to building a healthier carrot.


Michael Kellett Photography
Texas Fruit Citrus fruits contain limonoids, which may help prevent cancer. Researchers are trying to maximize Texas grapefruits' high level of limonoids.

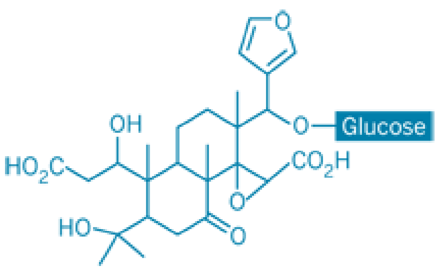
More than a decade later, Pike's maroon carrots are known to grocery store patrons as BetaSweets. They also sell in the form of presliced carrot "coins" called BetaBites, which display their orange core and maroon-purple edge. The carrots' unusual coloring stems from high levels of anthocyanins, a group of antioxidants that give various fruits and flowers a purple hue and are touted as being able to inhibit the growth of cancer cells. β-Carotene, a fat-soluble terpene and antioxidant, gives regular carrots their characteristic orange color and converts to vision-improving vitamin A in the human body. Human trials investigating the effect of maroon carrot juice on breast cancer are scheduled to begin soon at the medical schools of Texas A&M and the University of Arizona.

Pike's carrots reflect the recognition among both researchers and the public that a healthy diet starts in the field, and momentum for nutritional improvement of several food crops is building. The number of published papers exploring the properties of bioactive constituents of foods has quintupled since 2003, showing that researchers are interested in parsing out exactly what cocktails of bioactive compounds are good for us, says James Seiber, director of the Department of Agriculture's Western Regional Research Center (WRRC) in Albany, Calif., and editor of the *Journal of Agricultural & Food Chemistry*, published by the American Chemical Society. The public is interested because they have heard results of epidemiological studies, for example, that say drinking cranberry juice or eating blueberries could help prevent certain diseases, he adds.

Creating healthier foods that appeal to consumers is a collaborative effort that combines the talents of chemists, nutritionists, food scientists, horticulturists, physiologists, medical experts, and plant breeders. The teams are using analytical chemistry techniques and traditional breeding methods rather than the biotechnology and genetic engineering that would be needed to, for example, grow a banana that could serve as an edible vaccine.

Nutritionists usually first discover that a whole fruit provides a particular health benefit in clinical studies. Chemists then determine the responsible component. Next, plant breeders increase the amount of that component in the offspring plants. Chemists, food scientists, and nutritionists work together again in human trials to test the nutritiona efficacy of the isolated component.

Pike had applied traditional breeding on several different crops before using it to increase amounts of antioxidants i the maroon carrots. Another group of researchers is breeding out negative factors such as certain fatty acids from corn to make healthier oils. Some researchers are hoping a modified soluble fiber that lowers cholesterol even more than traditional bulk fiber may soon find its way into ready-to-eat products such as tortillas, pasta, and cakes. Yet other researchers are investigating the effect of harvest time on food chemistry by, for example, pinpointing when grapefruit should be picked to maximize the levels of certain anticancer compounds in the fruit.



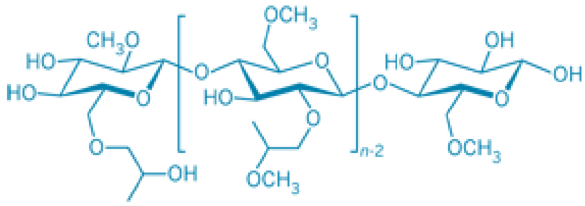
Deacetylnomilinic acid glucoside

GRAPEFRUITS GROW in warm climates, including California and Florida, but the reddest and sweetest varieties come from Texas. These highly prized Texas grapefruits have piqued the interest of food chemists because they contain high levels of several bioactive compounds, including limonoids. Animal and cell culture studies show that limonoids may reduce the risk of several cancers, including oral, stomach, and colon cancers.

Limonoids are colorless, highly oxygenated triterpenoid compounds that are unique to citrus fruits. Researchers have speculated that the compounds, which contain a furan ring, may prevent cancer by activating enzymes called glutathione S-transferases. These enzymes can transform harmful substances into more water-soluble forms that can be excreted from the body.

Chemists want to understand limonoids' structure-activity relationships and learn how to maximize levels of the bioactive compounds in Texas-grown grapefruits, says Bhimanagouda S. Patil, director of the Vegetable & Fruit Improvement Center at Texas A&M. He notes that growers think the improved fruits would give them a niche in the marketplace.

SOLUBLE FIBER Fortefiber (generic structure shown) is made by modifying cellulose from trees.



Patil explains that there are two ways to enhance bioactive compounds such as limonoids: by boosting their biosynthesis via traditional breeding techniques or by isolating the precursor compounds, making structural modifications, and adding the bioactive compounds to the final juice or processed product. Some bioactive compounds could be synthesized from scratch, but a more efficient strategy, Patil says, might be to pinpoint, using analytical techniques, the time during the growing season that the compounds are most abundant in the natural frui For instance, the Texas grapefruit growing season is from October to May. Patil's group noticed that levels of certai limonoids, such as deacetylnomilinic acid glucoside, are very high earlier in the season. This means that clinical researchers doing studies with whole fruit should note the point during the growth cycle when the subject eats the fruit, Patil says.

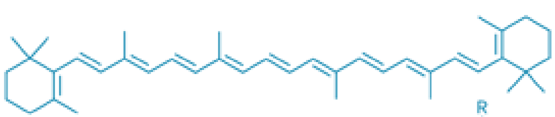
In addition, researchers have found that bioactive compounds can degrade during storage. Therefore, fruit that is harvested and stored adds a level of complexity that may not be addressed in many health studies, Patil suggests.

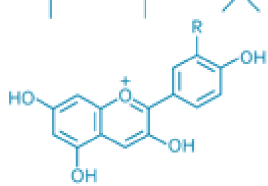
Previous laboratory studies show that feeding grapefruit pulp to rats with cancer improves the rats' recovery rate. Trials with citrus products in patients recovering from breast cancer treatments are scheduled to run at the medical schools of Texas A&M and the University of Arizona.

As consumers hear and read more about the perils of high cholesterol and obesity, the pros and cons of edible oils continue to splash across health-related headlines. For example, numerous stories based on clinical studies indicat that people who subsist on traditionally Mediterranean diets, which include a lot of olive oil, have healthy weights and cholesterol levels.

Although everyone seems to grasp that too much, or the wrong kind, of oil can be hazardous to their health, people aren't about to give it up. Pamela J. White, a food chemist at Iowa State University, explains that every culture likes to fry some sort of food in oil because the process adds crispness, flavor, and unique texture.

TO THAT END, food researchers attempt to appease consumers' taste for oil while preserving their health. For thei part, White and other researchers are focusing on altering the chemical composition of corn oil using breeding and analytical techniques to make healthful salad oil or frying oil.





HUE'S WHO β-Carotene (top) makes carrots orange, and anthocyanins (such as the example shown here, right) add a purple color.

That project is not as easy as it may seem. The researchers' tinkering is focused on complex combinations of five fatty acids found in edible fats and oils, the levels of which have various effects on health and taste.

The five major fatty acids in edible fats and oils are grouped according to their carbon-carbon bonds. Palmitic and stearic acids have only single bonds. Oleic acid has one double bond. Linoleic acid has two double bonds, and linolenic acid has three double bonds. To simplify food labels, nutritionists group palmitic and stearic acids under saturated fats, oleic acid as monounsaturated fat, and linoleic and linolenic under polyunsaturated fat.

Finding the right balance of fatty acids that meets criteria for taste, health, and function is tricky, White says. To taste good, oils have to have certain amounts of particular fatty acids. But oils must have other fatty acids to maintain a shelf-life and not degrade in a fryer. And the corn plant itself needs certain fatty acids to impart strength to cell structure so the plant can stand up in the field and provide good crop yields. Linoleic acid contributes to good taste, but is not very stable in frying and storage. Oleic acid has been shown in clinical trials to reduce low-density lipoprotein, or "bad" cholesterol. But a corn oil made with 70% oleic acid would impart a bland, waxy taste that is no very desirable, White says.

White works with Linda M. Pollak, a corn breeder, and Susan A. Duvick, a plant biologist, both with USDA's Agricultural Research Service at Iowa State. Pollak breeds the plants and extracts samples of corn, and Duvick analyzes the corn's fatty acid content with a gas chromatography method. The trio takes the varieties with the most promising fatty acid profile to a pilot plant on campus to be processed into oils, which are tested for taste and performance in storage or for applications, most notably frying.

White and Pollak have been working to modify the fatty acid composition of corn oil for nearly two decades. Even with fast analytical methods, the research is time-intensive because it can take years to breed the plants, grow the crops, harvest the corn, analyze hundreds of samples, process them into oils, and test their performance. White, Duvick, and Pollak are now cooperating with EnerGenetics International, a private Iowa-based agricultural research company, to test the oils in food applications, improve the agronomic traits of the corn so it will be more profitable fo farmers to grow, and provide samples to food companies.

FIBER ALSO frequently grabs news coverage. Studies have shown that fiber in foods and bulk fiber supplements can lower cholesterol, reduce the risk of colon cancer, and generally help people lose weight and control diabetes by maintaining lower levels of blood glucose.

Fiber-filled foods and supplements, with their bland taste and rough texture, however, are not consumer favorites. For the same reasons, many people don't like to eat whole-grain breads or skins of fruits and vegetables. Psyllium powder or other bulk fiber supplements add unappetizing black flecks or an unpleasant thick consistency to drinks.

But what about a fiber product that is designed to target a specific health-related purpose such as lowering cholesterol and is disguised in yogurts and desserts, soft breads and tortillas, and snack foods? Dow Wolff Cellulosics hopes its new food additive Fortefiber will fit the bill.

A few years ago, Wallace H. Yokoyama, a research chemist at USDA's WRRC, was studying how consuming modified cellulose reduces metabolic diseases in hamsters. He found that the soluble fiber helps keep blood sugar from spiking too high, a problem in diabetes.

So Dow Wolff Cellulosics asked Yokoyama to collaborate on studies of Fortefiber, a water-soluble material created from the microcrystalline cellulosic pulp of a tree, the species of which the company declined to disclose. The additive is commercially available as a thickening agent, and the polymer lengths can be custom-designed to achieve specific food textures or to accommodate different formulations, ranging from liquids to snack bars.

The proprietary, colorless semisynthetic compound is based on hydroxypropyl methylcellulose (HPMC), a compound that has been modified in hundreds of ways since Dow developed it 60 years ago as an alternative to animal gelatin in capsules, for example. Removing excess hydrogen bonds from cellulose makes HPMC-based molecules soluble.

Michael Kellett Photography

Maroon Carrots Anthocyanins—antioxidant compounds that turn flowers, fruits, and the edges of these carrots violet—may help prevent certain cancers.

Clinical trials demonstrate that Fortefiber can reduce high blood glucose levels. It's the same for low-density lipoprotein. The product is not found in stores yet, but Dow Wolff Cellulosics hopes to blend Fortefiber into ready-to-eat foods or to market it in supplement form as a powder or tablet, says Maciej Turowski, an analytical-chemist-turned-technical-marketing manager for the company.

Although these new food research avenues show promise, the transition from lab to table isn't guaranteed to suddenly boost public health. People have historically resisted dramatic changes in diet unless the shift is toward something that really tastes good. Clinical studies indicate that antioxidant compounds called polyphenols, which are found in grapes and other berries, boost cardiovascular health. But "it doesn't taste good to dump old red wine i potatoes," says John W. Finley, chair of the food science department at Louisiana State University.

THE GLUT of nutritional advice flooding the public could make it difficult for fortified or functionalized foods like Fortefiber and BetaSweets to get a hold in the food market, Finley worries. He cautions that the myriad of products available in health stores with outrageous and possibly dangerous claims could bias people against these science-based innovations. For instance, consumers see many products "fortified" with ginseng or green tea, but the levels of these components are either undeclared or so low that they provide little or no benefit, he says.

Also, scientists still have questions to answer. Adding various nutrients to a number of foods and juices may be too much of a good thing, says Jeffrey B. Blumberg, director of the USDA Antioxidants Research Laboratory and professor of nutrition science and policy at Tufts University. For example, it remains to be seen whether extra fatty acids, limonoids, or anthocyanins could be toxic if consumed in the increased amounts. In addition, he points to dat showing that antioxidant activity in the lab may not translate to bioavailability in the human body.

In time, science might in fact help identify an ideal diet. For now, the old standards of eating many different foods and in moderation are still the best guides.

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- Understanding Healthier Foods With Analytical Chemistry
- Figuring out exactly what's in the food you eat calls for chemists and their analytical instrumentation

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[Top of Page]