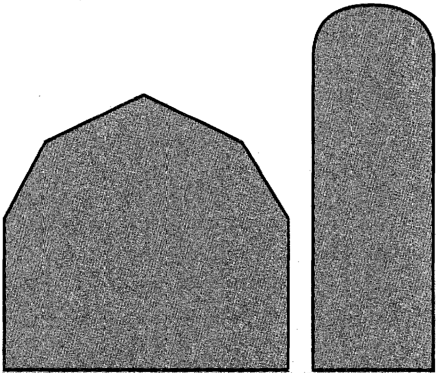


Part VI. Innovative Products for Food Industries

35 For Consumer Convenience: New and Improved Quality Food Products

by Antoinette A. Betschart, Director, Western Regional Research Center, and Glenn Fuller, Research Leader, Crop Improvement and Utilization Research, Western Regional Research Center, ARS, USDA, Albany, CA

Americans deserve the best food that science and technology can provide. They like to eat, but they want to be certain that what they consume is nutritious, safe, and pleasing to the palate. For over 100 years, USDA researchers with the Agricultural Research Service (ARS) have played a leading role in introducing and improving foods in the United States.

In its early years, USDA research was directed toward the farmer by providing new crops and by increasing the yields of major crops. Recently, the consumer's needs have furnished important goals for ARS scientists, who work to improve the safety, taste, and nutritional quality of foods. New knowledge in biochemistry, plant and animal physiology, and especially genetics has led to more information from the laboratory that supplements breeding research in the field. The techniques and methods used to develop new and improved foods from plants are described here.

New and Hardier Crops Through Preservation of Plant Species

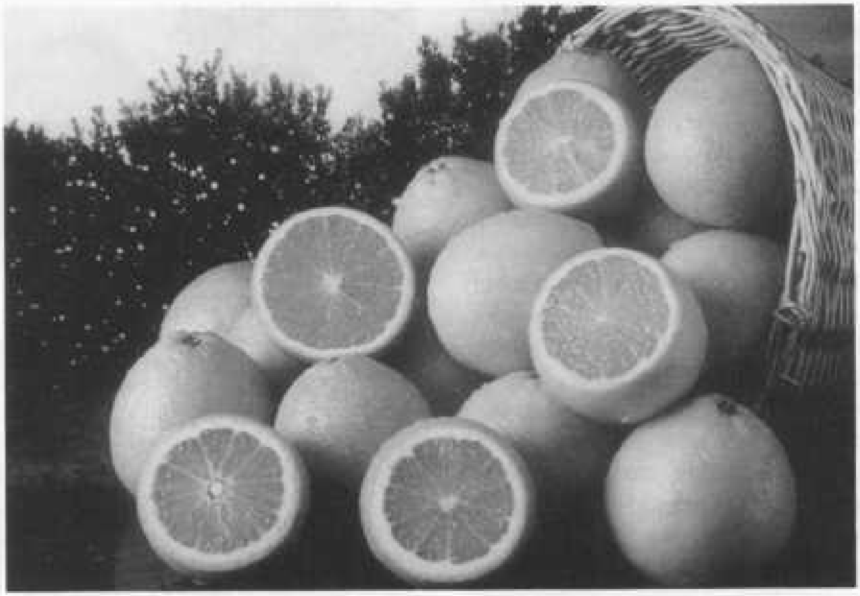
There is increased awareness that many species of plants and many strains within species are endangered because of the loss of habitat and because of cultivation of only the few varieties that produce the best yields. To avoid potential losses of species and strains, some ARS scientists spend significant parts of their careers searching the world for plant varieties. To preserve these species and lines, the National Plant Germplasm System (NPGS) was established for the collection, evaluation, preservation, and distribution of plant germplasm throughout the world. (Germplasm is the seeds or other parts of plants that can be grown into whole plants with inherited characteristics.)

Germplasm is difficult to preserve, since many kinds of plant seeds and propagative tissue do not store well and must be grown and recovered periodically. Promising research is in progress to store viable seeds and tissue at liquid nitrogen temperatures

(-320 °F) for many years, to reduce the labor and time required with present procedures. Many of the stored varieties of plants may be sources of important traits, such as disease and insect resistance or cold-hardiness.

In 1989, ARS scientists introduced a new variety of orange, called Ambersweet, in Florida. It had taken 26 years to bring out this new hybrid, which has the trait of cold-hardiness. Ambersweet trees were able to survive freezes of 18 °F without twig damage. Because the evaluation of each generation requires waiting several years for the young tree to bear fruit, it takes an especially long time to breed new varieties of trees.

Through systematic searching, unusual crops unfamiliar to most U.S. consumers have been found, especially tropical and subtropical fruits that may be grown in Hawaii, Florida, or southern California. Carambola, or star fruit, for instance, is now finding markets in Hawaii and on the mainland. Other interesting fruits under investigation include rambutan and lychee. Lychee, familiar to consumers of Chinese cuisine in the United States, is a soft and tasty fruit with milky-white flesh. It may be eaten fresh, canned, or preserved. Rambutan, a relative of the lychee, is a native of Malaysia. Its spiny-looking skin can be easily removed to reveal a sweet, crunchy, juicy fruit, which may



In 1989, ARS scientists introduced a new variety of orange, called Ambersweet, in Florida. Ambersweet trees can survive freezes of 18 degrees F without twig damage.

Randall Smith/USDA 92BW0838

be eaten fresh or cooked. Another candidate for the market is the pili nut from the Philippines. These nuts are high in oil and protein, and have a distinctive flavor when roasted.

Better Fresh Produce Through Biological Laboratory Techniques

The scientific breeding of plants has been immensely successful in creating and improving crops, but it is slow. New characteristics have to be found (if they exist) in the germplasm. Then the traits must be laboriously incorporated into the plant by crossing them repeatedly, for several generations, with a variety that has other good characteristics. Today, laboratory techniques based on plant physiology and biochemistry may accelerate the process of creating, identifying, and incorporating new and useful traits.

Grape breeding is one example. For a long time, the Thompson Seedless grape was the only significant seedless variety grown in the United States. It is a popular table grape and makes a good seedless raisin but does not have a strong grape flavor. In 1973 scientists with ARS in Fresno, CA, introduced the Flame, a seedless grape variety that has greatly increased the market for red table grapes. More recently, they used conventional breeding techniques to produce three more new grapes: Crimson Seedless, Autumn Seedless, and Fantasy Seedless.

Tomorrow's seedless grapes may be the result of a laboratory technique known as embryo rescue. Seedless grapes are not really seedless; their seeds just don't develop. Using embryo rescue, ARS researchers capture immature seeds and, by proper culture of these seeds, produce new lines of seedless grapes from two seedless parents. Varieties resulting from embryo rescue may be available soon, giving the consumer more variety in table grape flavor and tasty seedless raisins.

Tomatoes grown for processing into paste, catsup, and sauces normally have a solids content of 5 to 5.5 percent, and the rest is water. A scientist at ARS' Western Regional Research Center (WRRC) in Albany, CA, has used a combination of laboratory procedures to develop tomato lines with 8 to 12 percent solids. Tomato plant parts are placed on a gel-like mix of nutrients, where they grow as a clump

Robert Knight, an ARS horticulturalist, displays the cross section of a carambola or star fruit to show the distinctive star shape. Markets for carambola are increasing in Hawaii and on the mainland.
Barry Fitzgerald/USDA 0786X886-22

of tissue. In this form, many of the plant's genes will vary. The growth medium is adjusted to select tomato cells that are capable of producing more solids. Cells that survive are nurtured into mature plants that produce tomatoes with higher-than-normal solids content. Second and third generations of many of these plants still carry the high-solids trait. Estimates are that each additional percent of solids in the U.S. tomato crop is worth $70 to $80 million annually in energy cost savings to industry. The new high-solids lines, now being incorporated into hybrids by a major seed company, will benefit the consumer by decreasing costs and improving quality.

ARS scientists at Salinas, CA, produced miniature iceberg lettuce heads that range in size from tennis balls to grapefruit, by treating ordinary lettuce seed with a chemical. The seed then produces lettuce plants that are deficient in a plant growth hormone, gibberellin. The mini-lettuce is a convenient size for small families or for singles.

Finally, scientists at Albany, CA, are using a technique called protoplast fusion to move needed traits from one type of plant into another species. By fusing protoplasts (cells with the cell wall removed) of tomato with those of tomatillo, researchers hope to bring the tomatillo's additional insect resistance to the tomato.

Lychee, a sweet tropical fruit, is a good source of vitamin C. The Florida lychee crop, shipped primarily to the east coast and Midwest, is worth almost $2 million a year.

Barry Fitzgerald/USDA 0786X886-6

Superior Wheat, Potatoes, and Tomatoes Through Genetic Engineering

Currently the most glamorous of the biological methods of plant modification is genetic engineering, the systematic alteration of DNA coding for the proteins of an organism. It is possible to create altered DNA or to incorporate a specific segment of DNA from another species, but this is not a simple process. Permanent change or transformation of a plant requires the incorporation of new DNA into the chromosomes along with pieces of DNA promoting "expression" of the gene (the actual process of converting the code into a protein). Several scientists at Albany, CA, are modifying plants this way.

One WRRC group is working to improve wheat through genetic modification of a group of proteins called glutens, which are responsible for the ability of wheat flour doughs to retain gas bubbles and "rise." The process of "transformation," or placing new DNA into wheat, cannot be done by the methods used to bring new DNA into some other crops, such as tomatoes or potatoes. When scientists find out how to perform wheat transformation consistently, they may be able to improve not only bread's quality but also its nutritional characteristics.

Another scientist at WRRC is directing experiments to correct an important problem of potatoes. Bruised potatoes develop black spots that are not visible through the skin. These

Graduate student Linda Lee and plant physiologist Richard Emershad transplant seedless grape varieties from growth chamber containers to soil plots in the greenhouse.
Jack Dykinga/USDA 89BW1906-28

Better, sweeter, juicier grapes are the goal. Four new varieties produced by the Agricultural Research Service are Crimson Seedless, Autumn Black, Fantasy Seedless, and Autumn Seedless.
Jack Dykinga/USDA 89BW1911-4

spots are the result of oxygen in the air reacting with an amino acid, tyrosine, in the presence of a potato enzyme. The strategy: give potato plants a new gene that will direct a protein to use up the tyrosine.

At the University of California/ ARS Plant Gene Expression Center, a group has controlled tomato ripening by incorporating "anti-sense" RNA that blocks the action of an enzyme. This enzyme is needed for the formation of ethylene, a hormone that promotes tomato ripening. Tomatoes having this gene will stay green on the vine for long periods. Then, when desired, ripening may be triggered by exposure of the fruit to ethylene gas. The technique will provide the optimum number of ripe tomatoes at a specified time.

Safer, More Nutritious, and Tastier Cereal Products, Fruits, and Vegetables Through Postharvest Research

Much of the abundance in the American diet is the result of what is done after crops are harvested. The system we have for storing, transporting, and processing food allows quality products to be sold year-round, although harvest may occur only once a year. An important goal of agricultural research is to bring food to the consumer with the best flavor and nutritional quality. This means that the texture and taste must be very close to those of the fresh product.

Many new and improved foods have resulted from postharvest research. The objective of one project at WRRC is to develop lightly processed fruits and vegetables in order to decrease the shipping cost and to improve consumer convenience. A method called dehydrofreezing is beginning to be used in the marketplace. In this method, fruits and vegetables are cut or peeled, some of the moisture is removed, and then the produce is frozen. The partial dehydration prevents cellular damage and results in fruits or vegetables with near-fresh texture and flavor. After the produce has been thawed and water has been added, it may be used in cooking or baking. Dehydrofreezing results in products, such as pies or baked goods, that have fresh texture and flavor.

Peeled or cut produce loses liquid and turns brown. Coatings that are tasteless and safe to eat would protect lightly processed products from water loss, air exposure, and spoilage from bacteria. WRRC scientists have devised coatings derived from carbohydrates, proteins, or fats, depending on the nature of the protection desired. These coatings can form an edible barrier between pizza and its topping, or bread and its jelly, so that pizzas and sandwiches don't become soggy.

Scientists at WRRC have been pioneers in the study of flavor. Recently a group analyzed the flavor of cooked tomatoes and found that although there are hundreds of components of tomato flavor, a mixture of only seven of these components can be used as a tomato-flavor enhancer or tomato seasoning. The tomato flavor discovery was patented and is being investigated by several large food companies.

Rice bran (the brown outer coating that is milled from rice grains) is 10 to

12 percent of the weight of polished rice. It has been used mainly for animal feed because it contains an oil that rapidly turns rancid, making it unsuitable for food products. A group of scientists at WRRC put the bran through a machine known as an extruder. By rapid uniform heating this stabilization process inactivates the enzyme responsible for the rancidity. Stabilized bran may be used in baked products, or oil may be extracted from the bran for salads or cooking. Nutritional experiments with humans and laboratory animals have shown that stabilized bran helps to decrease low density lipoprotein (the so-called "bad" cholesterol) in the blood. The same researchers have used a dry milling process to obtain high-fiber fractions from oats and barley that may find use in bran-containing breakfast products and baked goods. Many people are allergic to the wheat gluten proteins that are necessary to make a good loaf of leavened bread, but they are not allergic to the proteins of rice. Scientists at WRRC invented the technology to make a yeast-leavened bread from rice flour by using a gum ingredient that gives rice dough the strength to rise and form a loaf.

The Future

Many of the food products described in this chapter are already in the marketplace. Others may be introduced during the next few years. Research will continue to produce safer, more nutritious, innovative foods through the use of biotechnology and genetic engineering. Our goal is to maintain our country's place as one of the world's best-fed nations, and to enhance its position as a source of high-quality food for the rest of the world. ❑