Better Than the Real Thing

Industry serves up the fruits of tomato biotechnology

By DANIEL PENDICK

Pity the supermarket tomato. Pale red and unyielding to the touch, it lacks the vibrant color and luscious flavor of a ripe, fresh-picked fruit. Yet, despite their dissatisfaction with mass-produced tomatoes, U.S. shoppers still buy an impressive 2.8 billion pounds of them every year.

Now, through advances in molecular biology, genetic engineers are gaining more precise control of tomato ripening and its effects on taste, texture, color, and shelf life.

The first of such gene-spliced products is well on its way to market. Genetic engineers from Calgene Fresh, Inc., have created the "Flavr Savr," an alternative to the beleaguered supermarket tomato. This engineered tomato, designed to resist softening, will have the fresh flavor consumers desire and an extended shelf life as well, Calgene contends. If and when federal officials issue a favorable opinion on Calgene's tomato, the Evanston, Ill.-based company will splice its genetically engineered fruit into the human food chain. This could happen as early as next year.

Reaction to the imminent arrival of Flavr Savr on supermarket shelves has varied. To promoters of biotechnology, Calgene's tomato heralds a new cornucopia of genetically engineered fruits and vegetables. Critics of gene-spliced food seem to fear a real-life enactment of the cult science-fiction film "Attack of the Killer Tomatoes."

The Foundation on Economic Trends

Genetically engineered food products, including Calgene's Flavr Savr tomato, won't make it to the supermarket without opposition.

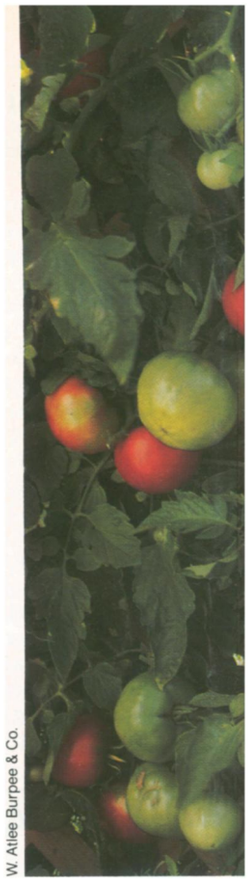
Consumers may soon have the chance to decide for themselves, however. Several companies besides Calgene have developed their own gene-spliced tomatoes and intend to put them on the market in the next few years.

Much of this tomato tinkering aims at remedying the shortcomings of current tomato-farming practices. Growers of fresh-market tomatoes harvest their crop firm and green so it can be washed, sorted, packed, and shipped without suffering extensive (and expensive) bruising. Before shipping, commercial packers bathe the tomatoes in ethylene gas for several days to spur ripening.

The problem is, says Mark Stowers of the Monsanto Co. in St. Louis, these prematurely plucked and artificially ripened tomatoes just don't have the flavor consumers desire.

From a grower's viewpoint, the ideal mass-production tomato could be left on the vine to build up the sugars and acids critical to fresh taste and aroma, yet remain firm enough to handle without damage. This is exactly what Calgene claims to have done.

Using a technique called antisense genetics, Calgene researchers permanently endowed their tomato with a backward (antisense) copy of the gene for polygalacturonase (PG), a fruit-softening enzyme. Both copies of the gene produce messenger RNA, which carries genetic information from the nucleus to protein-making ribosomes in cells. However, the antisense RNA molecules bind to the normal, "sense" RNA. This prevents the tomato from making the usual amount of PG. As a result, the tomato can remain longer on the vine without getting too soft for handling, says Calgene, and it can also hold up longer in the produce department.



W. Atlee Burpee & Co.

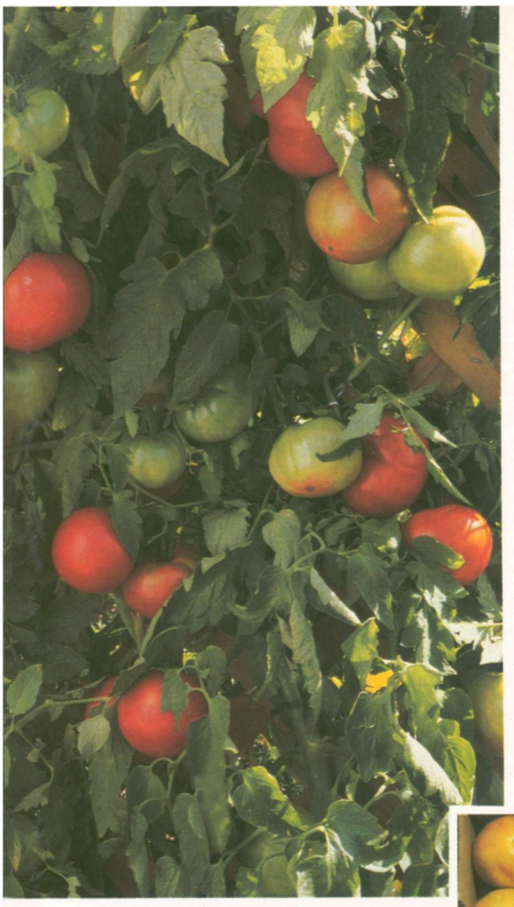
A favorite with home gardeners since 1949, the "Big Boy" hybrid tomato produces meaty, thick-walled fruits weighing up to a pound, says seed developer W. Atlee Burpee & Co. Genetic engineers hope to design tomato varieties for large-scale farming that have more of the flavor, feel, and color of garden-grown fruits.

Antisense genetics is more than just a tool for customizing tomatoes. Scientists have used the technique to discover some very important things about the ripening process, says plant molecular biologist Athanasios Theologis in a review article in the October PLANT CELL.

For example, Theologis and others at the U.S. Department of Agriculture's Plant Gene Expression Center in Albany, Calif., confirmed last year that ethylene is the master control hormone of ripening in many plants. Theologis' group used antisense genetics to cut production of ethylene to such an extent that green tomatoes remained on the vine for as long as five months, ripening only to a pale orange.

Tomatoes and many other plants produce ethylene to control the various biochemical processes that cause fruit to ripen, including the breakdown of chlorophyll, the synthesis of the red pigment lycopene, the buildup of sugars and acids, and the softening of tomato tissue by PG and other enzymes.

Some genetic engineers have chosen ethylene control as a means of tailoring tomato ripening to growers' needs. Monsanto's agricultural research group, for example, has outfitted its tomato with a bacterial gene whose enzyme digests an acid called ACC, the raw material that tomato cells convert into ethylene gas. Stowers, who is business director of Monsanto's tomato project, says that growers



DNA Plant Technology Corporation

Commercial tomato growers must pick mostly premature, firm tomatoes so they can be processed and shipped without large losses from bruising or overripening. Unfortunately, these "mature green" fruits don't taste as good as the farm-fresh tomatoes many consumers would like to have year round.

can leave these ethylene-deprived fruits on the vine for three or four more days — just long enough to build up extra flavor.

In addition to the quest for a better fresh-market tomato, genetic engineers want to carve out a place for themselves in the tomato-processing industry — and the size of this market is impressive. Every year, U.S. processors transform 12 billion pounds of raw tomatoes into juice, sauce, paste, ketchup, and other products. Part of this crop goes into the 315 million cans of Campbell's tomato soup consumed annually in North America.

The best tomato for making these products is high in solids, chiefly the sugars fructose and glucose. And tomato solids are no small potatoes: Indeed, the tomato-processing industry estimates that a 1 percent increase in tomato solids could save $70 million to $80 million a year in processing costs.

Using antisense genetics, Avtar K. Handa of Purdue University in West Lafayette, Ind., serendipitously created a tomato with 10 percent more solids than current varieties grown for processing. He and his collaborators report the results of their antisense experiments in the June PLANT CELL.

Handa did not set out to build a better tomato. His group used the antisense technique to block the gene for an enzyme called pectin methylesterase (PME) so he could study its role in fruit softening. The high-solids trait, unexpected though welcomed, showed up during standard testing of the harvested fruit.

In tomatoes, PME works in concert with PG to break down pectin, a major cell-wall building block. During ripening, these enzymes slowly soften tomato tissues, leaving them susceptible to bruising and rot.

Currently, Handa does not know exactly why suppressing PME enriches the solids in tomatoes. He suspects, however, that the undigested pectin present in antisense-PME tomatoes becomes part of their solids content.

Handa expects to finish compiling the field-testing data on his high-solids tomato by year's end. At that point, a private company could begin shepherding the new tomato onto the market, he says.

Genetic engineers continue to search for patentable tomato genes. Researchers at ICI Seeds in Berkshire, England, for example, have isolated 13 tomato genes that affect fruit quality and have patented five, says Simon G. Best of ICI Americas, Inc., in Wilmington, Del.

Other genetically engineered crops will follow, Best promises. "Tomatoes are just the first crop, from which we've identified a lot of genes that have other uses in crops with related biochemistry," he says. ICI may eventually use its patented genes and techniques to create new kinds of peaches and melons.

DNA Plant Technology Corp., another company developing a genetically engineered tomato, also plans to deploy its gene-control techniques further afield. Robert Whitaker, managing director of research at the company's facility in Cinnaminson, N.J., envisions bananas, papaya, and cut flowers as logical targets for future efforts to ensure freshness through ethylene control.

If these products win consumers over, genetic engineering may generate as much new green stuff for supermarkets as it has on the stock exchange. But given public concern about food purity and past squeamishness about gene splicing, must the biotechnology industry gear up for a major defense of genetically engineered tomatoes?

Consultant Richard A. Herrett, a member of the board of directors of the Association of Biotechnology Companies (ABC) in Washington, D.C., thinks it unlikely that torch-bearing citizens will ever come looking for the Frankentomatoes of the future. On the contrary, Herrett believes consumers will respond positively if the industry makes clear the potential gains in quality and nutrition that genetically engineered foods may offer.

However, Jeremy Rifkin and his Foundation on Economic Trends in Washington, D.C., hope to generate an international boycott of genetically engineered foods. Says Ted Howard, leader of the group's boycott effort, "I really feel this is going to be an extremely hotly contested consumer issue."

Although the Foundation on Economic Trends continues to demand additional regulation, recent changes in government policy have moved increasingly toward deregulation of agricultural biotechnology companies in the United States. For example, USDA last month significantly loosened restrictions on field testing of genetically altered plants.

The U.S. Food and Drug Administration (FDA) is considering whether Flavr Savr should be treated the same as tomatoes produced by traditional breeding methods and whether the antisense gene added to the tomato poses any health risks, explains Eric Flamm in the FDA's Office of Biotechnology.

Andrew Kimbrell, attorney for the Foundation on Economic Trends, has already decided on one response to a favorable FDA ruling. "The minute FDA rules that this food does not need to be labeled, we will sue them," Kimbrell promises.

Should the FDA decide in Calgene's favor, the Flavr Savr tomato will take its place on grocery shelves and in history as the first genetically engineered whole-food product available to the consumer. Considering the hundreds of genetically engineered crops now in field trials, however, it will not be the last.

Even so, it is not clear yet that people's yearning for a better mass-produced tomato will translate smoothly into widespread acceptance of genetically engineered foods. In the end, gene-spliced tomatoes may prove as ripe for controversy as the technology that is creating them. □