BRIAN PRECHTEL (K9200-2)

Castor beans.

HIGH-TECH CASTOR PLANTS MAY OPEN DOOR TO DOMESTIC PRODUCTION

BRIAN PRECHTEL (K9197-1)

Plant physiologist Grace Chen removes castor bean pods to test for genetic transformation.

Inside the beans of the castor plant is a toxin seven times more deadly than cobra venom. Known as ricin, the compound's toxicity is one reason why American farmers no longer grow this crop extensively—even though a lucrative market exists for the castor bean's unique oil.

Components of the oil, known as hydroxy fatty acids, are essential for making high-quality lubricants for heavy equipment or jet engines, for example. Castor oil is also used in paints, coatings, plastics, antifungal compounds, shampoo, and cosmetics.

Allergens Pose Health Hazard

Besides the ricin toxin, there's another compelling reason why this crop has fallen out of favor with U.S. growers. The shiny, beetle-shaped seeds contain powerful allergens. People who work with the off-white meal ground from castor beans may develop allergic reactions, such as hives or asthma. In severe cases, they may go into anaphylactic shock, which can be fatal.

Conventional breeding to rid castor of lethal ricin and troublesome allergens hasn't solved the problem. But biotechnology might, according to Thomas A. McKeon of ARS' Western Regional Research Center in Albany, California. He and colleague Grace Q. Chen, both in the Crop Improvement and Utilization Research Unit, are the first in the world to genetically engineer castor plants.

In preliminary experiments, McKeon and Chen used marker genes to determine whether their tactics for shuttling new genes into plants actually worked. Now the scientists want to give the plants other genes—ones that could, among other things, block production of ricin poison and the powerful allergens.

Biotech Strategies

Scientists elsewhere have already isolated and copied a gene critical to ricin production, as well as a gene that produces the key allergen proteins in castor. McKeon and Chen aim to build and insert slightly different versions of those genes into the castor plant, to block the action of the ricin and allergen genes. For example, they want to construct antisense genes, which are genes that make nonsense copies of the authentic ricin or allergen genes.

"Antisense genes," McKeon says, "can interfere with the gene expression needed for producing ricin and allergens. That may leave the plant unable to form these compounds."

Castor plants that are free of ricin and allergens could renew interest in farming this crop. That could happen not only in the southern United States, where it was grown until the early 1970s, but also in the arid Southwest, where it could grow well if irrigated.

"Castor is a semitropical plant that thrives in sunny climates," McKeon says. Although some types of castor grow to be 30- to 40-foot-tall trees in the Tropics, in the United States castor can

BRIAN PRECHTEL (K9198-1)

A castor bean pod.

BRIAN PRECHTEL (K9198-2)

Chemist Thomas McKeon and Grace Chen remove leaf disk samples from genetically transformed castor plants to test for enzyme activity.

be harvested annually when it is only about 4 to 5 feet high. In the past, U.S. production has reached 1,000 pounds of oil per acre. "That's an impressive feat for any oilseed crop," notes McKeon.

Production of a U.S. castor crop could ensure a more reliable supply of the oil for American industries and for defense. This country depends on imports of castor oil, primarily from India. In 1999, America imported nearly 103 million pounds of castor oil, worth about $41 million. The world demand for castor oil is about 1 billion pounds annually, valued at more than $400 million.

Although some other plants, like lesquerella, can produce oil that contains hydroxy fatty acids similar to the ones in castor, these alternative crops are not yet widely grown commercially. Another approach? Synthesize hydroxy fatty acids in chemical factories. Although the technology exists to do that, growing castor plants outdoors in the sunshine is a more economical approach, McKeon says.

Epoxy Oil—A Possibility?

In addition to reviving production of castor, genetic engineering might someday be used to tweak its oil-producing mechanism so that it could yield another valued oil, known as epoxy.

Says McKeon, "There is a potential U.S. market of about $300 million a year for epoxy oil. An epoxy-based paint, for example, offers all the advantages of a premium, oil-based paint, yet does not give off certain volatile chemicals that pollute the atmosphere." That's unlike the solvents in oil-based paints, which can be an environmental hazard.

"We think that production of epoxy oil by castor plants is possible," says McKeon, "because the chemical structure of epoxy oil is very similar to that of castor oil. The modification that's needed to cue the castor plant to make epoxy oil instead of castor oil is minor. That's very different than trying to genetically engineer a corn plant or a soybean plant to make epoxy oil. The oils that those plants make are very unlike epoxy oil."

McKeon and Chen have produced about a dozen genetically engineered castor seedlings in their laboratory and greenhouse. They are applying for a patent for their discoveries (U.S. Patent Application No. 60/167,360, "Transformation of *Ricinus communis*, The Castor Plant").—By **Marcia Wood,** ARS.

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