CORN COPRODUCT CUTS ETHANOL PRODUCTION COSTS

The United States is the world's leading corn-growing country, with more than 40 percent of global production. More than 9 billion bushels were produced in 2001—the third highest yield on record, according to USDA's National Agricultural Statistics Service.

Where does all this corn end up? Most is used in livestock feed, but it is also processed into many food and industrial products. These include starch, sweeteners, corn oil, beverage and industrial alcohol, and ethanol fuel.

Corn is an abundant and renewable resource, and the search for energy alternatives makes it a natural choice as a fuel source. The high starch content of corn can be converted to sugar and then fermented to ethanol fuel by brewer's yeast.

Combining ethanol with gasoline lifts the octane level and makes a cleaner-burning fuel. In the 2000-2001 season, about 620 million bushels of corn were used in ethanol production, according to figures from USDA's Economic Research Service. This number could increase 10 percent in the 2001-2002 season. A federal tax exemption keeps ethanol economically competitive with petroleum fuel products but is due to expire in 2007.

PEGGY GREB (K9840-1)

Chemist Nick Parris spraying zein-lipid mixture onto brown kraft paper. These mixtures can be used to replace waxes made from refined petroleum-based products.

Cheaper Zein Means Cheaper Ethanol

Ethanol production from corn creates a surplus of byproducts that are increasingly difficult to sell. Engineers at the Eastern Regional Research Center in Wyndmoor, Pennsylvania, saw the potential to lower production costs of ethanol by making these byproducts more valuable, which could create new markets. The researchers believed one approach was to develop a less expensive process to separate a valuable protein—zein—from corn.

Zein is the main storage protein in the corn endosperm and makes up more than half the total mass of the seed protein. It is currently extracted from corn gluten. It is used mostly as an edible, water-resistant coating for nuts, confectionery products, or pharmaceutical tablets. Little zein is sold because it sells for about $10 a pound.

"In the dry-milling ethanol process, zein is found in dried distillers grain—or DDG—which is mostly sold as a protein supplement in livestock feed," says James C. Craig, the recently retired former head of the Engineering Science Research Unit, where the project originated. But as ethanol production expands, the supply of DDG is expected to far exceed demand. "We believed we could develop a process to extract the zein at a cost that makes it attractive as a commodity."

The researchers engineered and built a pilot ethanol plant at ERRC to find ways to improve the economic return of commercial corn-fermentation plants. The team broke the cost barrier for affordable zein with a system for bulk extraction. Their approach was to use the ethanol as a solvent to extract zein from dry-milled corn.

"A key cost-savings in this process is that the solvent, ethanol, is already present, since it's the primary product," Craig says. "After fermentation, part of the ethanol produced can be recycled to the extraction step, used, and then returned downstream for separation."

This method gives corn-ethanol plant owners an option of producing a value-added coproduct, zein, which would provide more revenue and reduce the overall cost of ethanol production. Efforts are now under way to determine the maximum concentration of zein that can be directly extracted from corn.

The pilot plant work was carried out under the supervision of chemical engineer Leland C. Dickey. Pilot plants model

commercial processes so that innovations can be evaluated in a realistic setting.

Finding Added Value in Corn Kernels

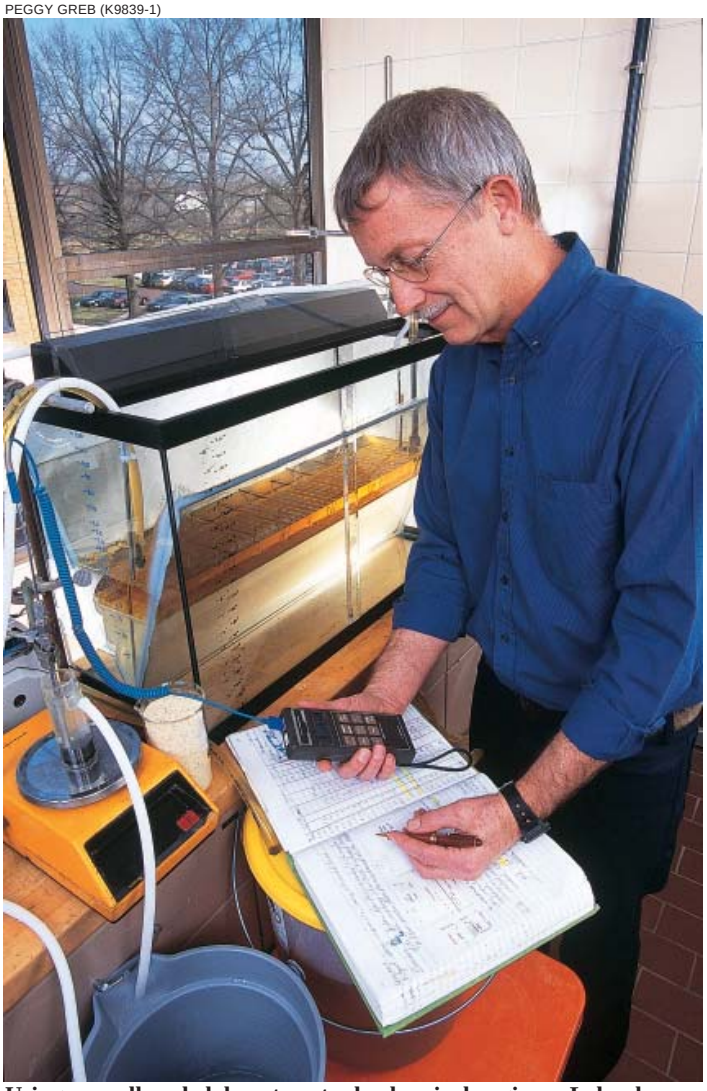
Traditionally, films made from commercial zein are too brittle and their tensile strength too low for most applications. Chemist Nicholas Parris is finding ways to improve the properties of zein isolated from ground corn.

Recently, ERRC scientists isolated a zein-and-lipid mixture from dry-milled corn that costs about $1 a pound to produce. While not as pure as the zein currently on the market, it is still well suited for many applications. The lipid in the mixture replaces refined petroleum-based products that are used to make wax paper and wax-coated packaging. The mixture is an excellent material for coatings, according to Parris, because the zein portion resists grease, and the fatty acids repel water. Because lipids eliminate use of paraffin wax, the paper can be recycled. Unlike petroleum-derived waxes, the zein-lipid mixture is biodegradable.

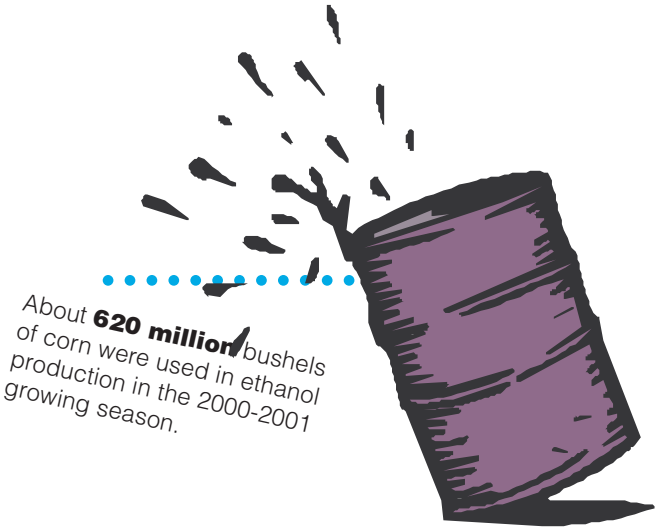
In the past, synthetic plasticizers have been used to improve the mechanical properties of films made from commercial zein. But Parris found that the presence of free fatty acids in the zein-lipid complex could have the same effect.

A computer simulation model was designed to make cost estimates for production from commercial plants. The models are based on data from ethanol producers, engineering firms, equipment manufacturers, and other sources. ARS cost engineer Andy McAloon provides support to scientists and engineers to determine research direction and the costs of possible alternatives to standard industry practices. He uses the program to predict the economic impact of the research.

PEGGY GREB (K9839-1)



Using a small-scale laboratory tank, chemical engineer Leland Dickey separates corn and extract liquid. The extract liquid will be further processed to separate out the zein.



ERRC researchers are seeking cooperators who have specific commercial requirements. The team can develop a process to extract zein with the purity and characteristics for a specific application at an affordable cost.—By **Jim Core,** ARS.

This research is part of Quality and Utilization of Agricultural Products (#306) and Bioenergy and Energy Alternatives (#307), two ARS National Programs described on the World Wide Web at http://www.nps.ars.usda.gov.

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