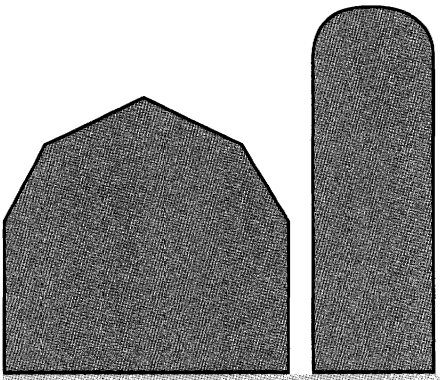


# Part I.
# Markets

# 1 Agriculture Provides U.S. Industry With Diverse Raw Materials

by Sam Brownback, Kansas Secretary of Agriculture, Kansas State Board of Agriculture, and Lewrene Glaser, Agricultural Economist, ERS, USDA, Washington, DC

U.S. agriculture is expanding its mission. It is rapidly transforming itself into a more diverse business of food, fuels, medicines, and materials.

Farmers and agribusiness have long desired to recover markets lost to the petrochemical industry during the last 50 years. The original nylon was made from corn cobs and now it is all petroleum based. Latex paints have replaced oil-based paints that were made with vegetable oils such as linseed and tung. Synthetic fibers have gained major inroads in textile markets, especially carpeting.

In recent decades, most of this interest in expanding markets for agricultural materials has been prompted by surpluses of traditional commodities, rather than by demands from the marketplace. That situation has radically changed today. Consumers are demanding more environmentally sensitive products. One way individuals want to help the Earth is by decreasing their own consumption of nonrenewable commodities.

Businesses are responding to consumers' concerns. They are also looking at their production systems in an environmental light. It is expensive to dispose of trash and toxic wastes. Increasingly, businesses are trying to minimize the creation of waste products during manufacturing and then to dispose of them in an ecologically sound manner.

Another factor that has changed the equation is agriculture's increasing ability to provide industry with raw materials at competitive prices. For example, the real (adjusted for inflation) price of corn has declined since World War II, while the real price of crude oil, a nonrenewable resource, has increased significantly (see fig.1). This bodes well for the position of agricultural materials compared with petroleum products.

Technological advances have also expanded the ability to competitively derive new, innovative products from agricultural raw materials. Corn and potato starches are being made into ethanol and polymers. Vegetable oils are ingredients in lubricants and inks. Plants and animals are providing doctors and patients with drugs and other complex biochemicals.

## Ethanol

Technological improvements, such as energy-efficient cogeneration of steam and electricity or inexpensive processes that separate ethanol and water, have lowered operating costs for modern ethanol plants. Ethanol is now a net producer of energy, according to a recent study by the U.S. Department of Energy. When it was originally produced in large quantities 15 years ago, it was a net energy consumer.

More than 95 percent of the Nation's ethanol is made from corn. But many small plants are using locally available materials—such as whey, molasses, and potato and brewery wastes—that would otherwise be disposed of in lower value uses or as waste products. Current U.S. production capacity for fuel ethanol is about 1.1 billion gallons per year, with facilities that will provide another 300 million gallons of capacity under construction.

The Clean Air Act creates new market opportunities for fuel ethanol as a component in oxygenated gasolines. The act's 1990 amendments designate 39 urban areas in the United States to sell oxygenated gasoline for at least 4 months a year in an attempt to reduce carbon monoxide levels.

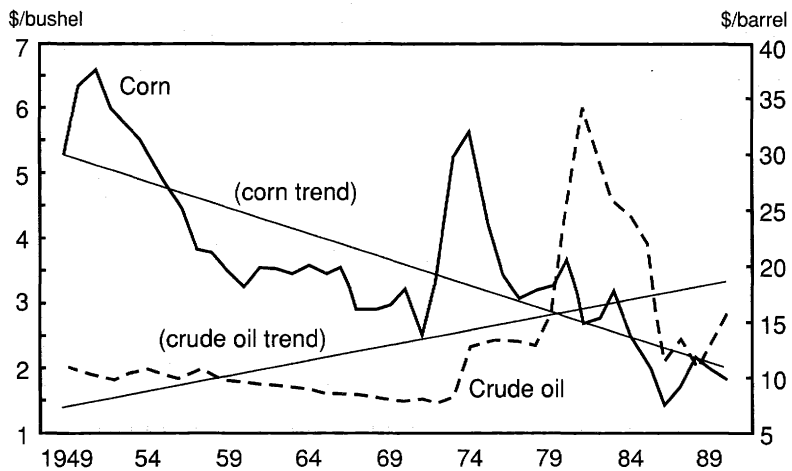
## Polymers

Not only is corn a raw material for ethanol, it is also used in the manufacture of moldable polymers. When starch-additive plastics first emerged less than 5 years ago, they contained 2-3 percent starch and 97-98 percent petroleum-based polymers. Today's technologies, however, use starch as the principal ingredient.

National Starch and Chemical Company has developed a biodegradable replacement for expanded polystyrene loose fill (packing peanuts) called Eco-Foam. Resembling a noodle-shaped snack, Eco-Foam is

Figure 1

**Real corn and crude oil prices, 1982=100**



100 percent corn starch. Output in 1991, the first year of production, was 2.5 million pounds. Currently, Eco-Foam is manufactured in nine U.S. locations. The market is large—50 million pounds of expanded polystyrene loose fill is used annually in the United States. Although Eco-Foam now costs about twice as much per pound as conventional polystyrene loose fill, its cost will probably come down.

Warner-Lambert's Novon Products Division is marketing a line of starch-based polymers derived from corn or potatoes. Production began in early 1992 at Warner-Lambert's facilities in Rockford, IL. The factory has an annual production capacity of 100 million pounds. Currently, NOVON polymers are used to make packing peanuts, candle cups for churches, and golf tees. Potential uses for NOVON include fast-food packaging such as cups, drink lids, straws, and cutlery.

Not only is corn a raw material for ethanol, but cornstarch is the principal ingredient in the manufacture of moldable polymers. *USDA SD-885*

Both Eco-Foam and NOVON will decompose in sewage treatment plants or in soil composts. One issue in the future will be the need to create compost centers that will take these totally degradable starch-based polymers and truly recycle them.

In addition, corn is now a common raw material for the manufacture of citric and lactic acids. These acids are widely used in diverse chemicals and polymers.

A company named Grand Metropolitan, in conjunction with the Michigan Biotechnology Institute, is developing corn-based protein polymer coatings as replacements for polyethylene and wax coatings on fast-food wrapping paper and paperboard containers. The new coatings are also good barriers to moisture and grease.

And what about edible plates made from wheat? Several foreign firms are in that business, and perhaps American companies soon will be producing edible tableware too. Future restaurant diners not only might order their meals, they might also specify the flavor of their plates!

## Vegetable Oils Have Many Industrial Uses

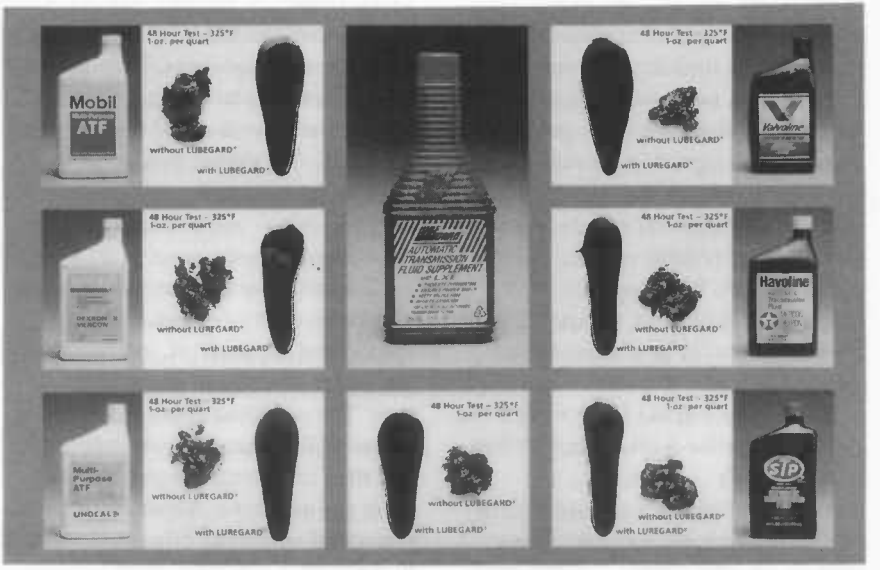
Fats and oils have long been used in the manufacture of soaps, fatty acids, paints and varnishes, resins, lubricants, and other industrial products. But their uses are expanding—replacing petrochemicals as raw materials in a number of new product areas. Spe-

cialty lubricants, newspaper inks, paints and coatings, and diesel fuel are just a few such examples.

**Lubricants.** A Seattle-based manufacturer of industrial lubricants, International Lubricants, Inc. (ILI), uses the unique attributes of various seed oils and their derivatives in its current line of automotive and industrial lubricants and lubricant additives. These products contain derivatives of industrial rapeseed, crambe, jojoba, or meadowfoam oils.

In addition to being partially derived from renewable agricultural commodities, these products have superior properties and are environment-friendly. For instance, ILI's Lubegard cutting oil has given the metalworking industry an excellent alternative to traditional chlorinated cutting oils. According to the company, Lubegard cutting oil's advantages include the following:

- Lower oil concentrations are needed in the coolant (a mixture of the cutting oil and water), which cools and lubricates metal parts while they are being cut.
- Workers' skin irritations and rashes caused by the harsh chlorinated oils are avoided.
- Cutting machines last longer and the parts being cut have smoother finishes.
- Once the coolant has reached the end of its useful life, the used oil and water are easily separated for disposal.




International Lubricants, Inc., a Seattle, WA, based industrial lubricants manufacturer, uses the unique properties of various seed oils and their derivatives. The company markets a line of automotive industrial lubricants and lubricant additives with the proprietary name Lubegard. These products contain derivatives of industrial rapeseed, crambe, and jojoba.
*USDA 92BW0780*

- The used oil is not classified as a hazardous waste, as are traditional cutting oils that contain chlorine, so disposal costs are decreased significantly.

ILI's ultimate goal is to develop products made entirely from seed oils that can be directly disposed of through water treatment facilities.

**Soybean Oil Inks.** First marketed in 1987, soybean-oil-based printing inks have experienced a phenomenal surge in usage. Over one-third of the Nation's daily and weekly newspapers are using either color or black soy ink. Color soy inks have been widely adopted because of their superior performance, despite their slightly higher price. Black soy inks are more expensive than their petroleum-based counterparts, thus limiting their use.

However, two environmental factors could encourage more newspapers and other lithographic printers to use soy inks: lower worker exposure to harsh petrochemicals and decreased emissions of volatile organic chemicals (VOC's). With soy inks, VOC levels are 2-4 percent, compared with 25-40 percent for petroleum-based inks.

Researchers at the USDA ARS National Center for Agricultural Utilization Research in Peoria, IL, are already working on a second generation of lithographic soy inks. They contain no petrochemical compounds (except for pigments), provide a wide range of viscosities, and are expected to be more cost competitive with petroleum-based inks.

**Paints and Coatings.** VOC's are one of the principal components in chemical reactions in the air that form ozone, which in the lower atmosphere is a pollutant that can cause respiratory problems. According to Environmental Protection Agency air pollution estimates for the United States, 18.7 million metric tons of VOC's were released into the atmosphere last year, down from a high of 25 million metric tons in 1970. As total emissions have declined in the last few years, so have emissions from transportation sources, primarily gasoline-powered vehicles. Industrial processes are now the largest source of VOC emissions.

Surface coatings are the largest single source of industrial VOC emissions. However, because paints and coatings are used in so many widely differing circumstances, they do not lend themselves to solvent recovery (where the solvent could be reused or recycled). Therefore, producers are looking for alternative raw materials to use in paints and coatings to meet EPA-required reductions in VOC's.

Scientists are examining vegetable oils, particularly vernonia oil and epoxidized soybean oil, as replacements for solvents in paints and coatings. The modified coatings have lower VOC's and superior properties, and they are cheaper than traditional paint formulations. About 50 million pounds of vegetable oils could be used in these applications annually.

**Fuels.** Biodiesels are receiving attention as a replacement for petroleum diesel fuel. Tractors and other farm equipment, commercial truck fleets,

railroad engines, barges, and military vehicles and ships all run on diesel fuel. Production agriculture alone uses 3 to 3.5 million gallons annually. Besides being a renewable resource, biodiesel fuel can also help reduce air pollution. It is low in sulfur and gives off fewer particulates during combustion. Research is being conducted to develop diesel fuel from soybean oil, rapeseed oil, and tallow.

## Drugs and Health Products

Plants and animals are increasingly being used to provide modern medicine with high-value drugs and biochemicals.

Taxol has recently emerged as a potent cancer-fighting drug. In clinical trials, it has shown significant activity against refractory ovarian cancer and good activity against advanced breast cancer. Further trials are in progress. Bark from the Pacific yew tree, *Taxus brevifolia Nutt*, is the current source of taxol. However, the long-term demand for taxol may outstrip this supply. Therefore, various projects are under way to find alternatives—from both domestic and wild sources.

For example, *Taxus* species are widely grown by the nursery industry as ornamental shrubs. Michigan-based Zelenka Nursery and researchers from the University of Mississippi and Ohio State University are demonstrating the feasibility of supplying dried needle and twig clippings from these plants

Ralph Shugert, staff horticulturalist at the Zelenka Nursery in Grand Haven, MI, samples a few of the millions of ornamental yew cuttings propagated by the nursery. Through a cooperative agreement with USDA and the National Cancer Institute, Zelenka Nursery will harvest, scientifically sample, dry, and ship enough yew needles and twigs to produce 2.5 kilograms of taxol. That would be enough to treat about 1,250 ovarian and breast cancer patients.
*Bob Nichols/USDA 92BW0735-10*

Professor Hala ElSohly, of the Research Institute of Pharmaceutical Sciences, University of Mississippi, Oxford, MS, examines a simple extraction of ornamental yew clippings before weighing and partitioning the solution to extract the taxol. The Zelenka Nursery provides the research material used at the university.
*Bob Nichols/USDA 92BW0595-19*

for taxol extraction. In tests at the National Cancer Institute, the clippings have had about twice the taxol content as does Pacific yew bark. Bristol-Myers Squibb will purify the drug and is pursuing commercialization of taxol from this source. In the future, perhaps the nursery industry will grow various plants for pharmaceutical uses.

Numerous companies are racing to produce human blood substitutes due to AIDS and other infectious diseases affecting the U.S. blood supply. A significant portion of the research is examining methods to extract the hemoglobin from cattle and pig blood for use in human blood substitutes. Research is also being conducted to develop animals that would produce pharmaceutical products for human consumption. For instance, Pharmaceutical Proteins, Ltd., a firm in Edinburgh, Scotland, has genetically engineered a sheep that produces a protein named alpha-1-antitrypsin (AAT) in its milk. The 1 in 2,000 people who are deficient in this protein can suffer pulmonary emphysema and irreversible lung tissue damage.

## A Promising Future

Although U.S. agriculture has made great strides in expanding its mission, the best is yet to come. The use of agricultural commodities as industrial raw materials will rise as nonrenewable resources become increasingly scarce and expensive, as businesses modify their manufacturing systems to use renewable materials and minimize waste generation, and as consumers use their purchasing power to indicate their concerns for a better environment.

Biotechnology promises enormous payoffs for agriculture. The ability to take a gene from one animal or plant and insert it into another will create

Frank Perez, a nurseryman at Zelenka Nursery in Grand Haven, MI, prunes 2-year-old ornamental yews with a combine. The combine was designed by Dr. Robert Holmes at the Agriculture Research and Development Center, Ohio State University. *Bob Nichols/USDA 92BW0736-25A*

market opportunities for a whole new class of commodities. For instance, tobacco plants are relatively easy to genetically modify and could be a future source of pharmaceuticals or other products requiring complex molecules. Microbial and enzymatic processes will be used to make the commodities and specialty chemicals that are the raw ingredients in nylons, polyurethanes, polyesters, and other polymers.

Continued technological improvements and effective partnerships between industry and Government will be paramount in achieving quick delivery of new products to the marketplace. Competition from abroad will be fierce as the agricultural industries in other countries look to these same fields.

Yet, if the United States takes advantage of its productive agricultural complex, along with its technological know-how, it should be able to provide a broad array of high-value products to consumers both here and abroad. U.S. agriculture will keep at its core the provision of food and fiber, but will continue to increase production of fuel, medicines, and industrial materials.

The transition to agriculture's new, expanded mission and marketplace will occur in this decade. It is an exciting time, with numerous opportunities for growth, expansion, and profit. Agriculture must seize the moment and bolster its capacity to produce what consumers desire—renewable bioproducts, made with the Earth in mind. ❑

# How New Products Find Their Place in the Marketing System

2

by Julie A. Caswell, Associate Professor of Resource Economics, University of Massachusetts at Amherst, Amherst, MA, and Warren P. Preston, Assistant Professor of Agricultural Economics, Virginia Polytechnic Institute and State University, Blacksburg, VA

New product introduction is a risky business. Successful new products can make a company and keep it competitive in its industry, while providing steady outlets for its input suppliers, such as farmers. However, failure rates are high, so it is very important for suppliers, manufacturers, and distributors to understand the forces that affect new product success.

A new product's path from development to market acceptance depends on the type of buyer targeted. There are two basic buyer types: intermediate users, such as processors and manufacturers, and final consumers. Marketing channels and the prerequisites of success vary depending on which is targeted.