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## Products Made from Corn

bioproducts • corn oil • ethanol • feed • sweeteners • starch

Corn refiners use shelled corn which has been stripped from the cob during harvesting. Refiners separate the corn into its components -- starch, oil, protein and fiber -- and convert them into higher value products.

- \* **Corn sweeteners** are the most important refined corn products. Last year, corn sweeteners supplied more than 56 percent of the U.S. nutritive sweetener market.
  - \* The second major refined corn product is **Ethanol**, which is gaining increasing acceptance as a cleaner burning option for motor fuels.
  - \* The third major corn product -- a mainstay of the industry and of the U.S. economy -- is **Starch**. Americans rely on corn refiners for over 90 percent of their starch needs.
- Corn refining is America's premier **Bioproducts** industry, with increasing production of amino acids, antibiotics and degradable plastics adding further value to the U.S. corn crop.
- In addition to starches, sweeteners and ethanol -- all made from the starch portion of the corn -- refiners produce **Corn oil** and a variety of important **Feed products**

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## SWEETENERS

Americans rely on corn for the majority of all the nutritive sweeteners they consume. Corn refiners produce three major classes of sweeteners: **corn syrups**, **dextrose**, and **fructose**.



### CORN SYRUPS

Mention corn syrups and consumers think of the sweetness and energy they offer--outstanding characteristics--, but their value as food ingredients also flows from their adaptability to many circumstances and their other, less-known, advantages. Corn syrups can depress freezing to prevent crystal formation in ice cream and other frozen desserts. Salad dressings and condiments pour at manageable rates because of corn syrups' effect on viscosity. In lunch meats and hot dogs,

corn syrups provide the suspension to keep other ingredients evenly mixed, and, like other corn products, the basic syrups can improve textures and enhance colors without masking natural flavors, as in canned fruits and vegetables. Refiners produce a variety of basic syrups to meet these needs, provide energy, and offer the right sweetness--enough but not too much--in thousands of foods Americans rely on.



### DEXTROSE

Dextrose is highly nutritious and easily digested because of its purity and because it is a standardized food form of the basic sugar which humans and animals absorb and use in their bloodstreams. An economical source of carbohydrates, it sweetens products like chewing gum lightly. In jams, jellies, preserves and icing mixes it is used to temper the intense sweetness of sucrose but offers another advantage; it maintains moisture so products don't go stale. Dextrose has

proved to be an excellent food for yeast to grow on during fermentation. The pharmaceutical industry is the single largest user of dextrose; it is the starting point for manufacturing vitamin C and is used in fermentation to produce penicillin and other antibiotics. Recently dextrose has gained importance in other fermentation applications--as a yeast food in brewing low calorie beers and as a feedstock for producing citric acid, lysine and other chemicals. In baking, another major market, dextrose again serves as a yeast food, but it also gives sweetness and improves the color and texture of breads, buns and rolls.



### HIGH FRUCTOSE CORN SYRUPS & CRYSTALLINE FRUCTOSE

High fructose corn sweeteners begin with enzymes which isomerize dextrose to produce a 42 percent fructose syrup. By passing 42-HFCS through a column which retains fructose, refiners draw off 90 percent HFCS and blend it with 42-HFCS to make a third syrup, 55-HFCS. Further processing produces crystalline fructose.

All the syrups share advantages--stability, high

osmotic pressure, or crystallization control, for example—but each offers special qualities to food manufacturers and consumers. 42-HFCS is popular in canned fruits, condiments and other processed foods which need mild sweetness that won't mask natural flavors. Sweeter 55-HFCS has earned a commanding role in soft drinks, ice cream and frozen desserts. Supersweet 90-HFCS is valued in natural and "light" foods, where very little is needed to provide sweetness. Crystalline fructose's capacity to produce greater sweetness in combination with sugar makes it useful in presweetened cereals, instant beverages and other dry mix products. ◀

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## ETHANOL

Ethanol, a pure alcohol made primarily by the corn refining industry, is today's alternative fuel. Henry Ford first suggested running cars on ethanol from corn, but it took the oil shortages of the seventies and the environmental problems of the eighties to turn ethanol into an important component in the American fuel supply. Ethanol-blended fuels account for 12% of all automotive fuels sold in the U.S.

Ethanol is made by fermenting sugars produced from corn starch. Many corn refining factories produce both ethanol and other corn products like starches and sweeteners so that capital and manufacturing costs can be kept as low as possible. While they are making ethanol, corn refiners also produce valuable coproducts such as corn oil and corn gluten feed.

Ethanol plays three major roles in today's economy and environment. First, it replaces about \$2 billion dollars of imported oil with a secure, domestic fuel. Second, it is an important component of gasoline reformulated to reduce pollution in cities which are not achieving air quality standards mandated by the Clean Air Act. And finally, it provides a major income boost to farmers and rural communities where most ethanol is manufactured. Ethanol, blended with gasoline at a 10% level or in the form of ethyl tertiary butyl ether (ETBE) made from ethanol, is effective in reducing carbon monoxide levels, ozone pollution and greenhouse gas emissions from automobile exhaust. ◀

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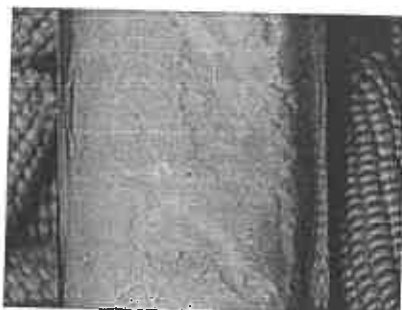


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## STARCH PRODUCTS

Starch is one of nature's major renewable resources and a mainstay of our food and industrial economy. Basic consumer necessities such as paper and textiles are major uses for corn starch in sizing, surface coating and adhesive applications. Corn starches, and their cousins dextrins (a roasted starch), are used in hundreds of adhesive applications. Special types of starches are used in the search for oil as part of the "drilling

mud" which cools down superheated oil drilling bits. Other key uses of starch in American industry are as flocculating agents, anticaking agents, mold-release agents, dusting powder and thickening agents.

Literally thousands of supermarket staples are produced using both regular and specially modified starches. Many of today's instant and ready-to-eat foods are produced using starches which enable them to maintain the proper textural characteristics during freezing, thawing and heating. Other starches are the backbone of instant pie and pudding fillings which require little or no cooking compared to traditional formulations.

The most promising new market for corn starches is as raw material for the production of industrial chemicals and plastics which are today made from petroleum feedstocks. As petroleum supplies dwindle or become less reliable, the importance of an abundant source of basic industrial chemicals takes on new proportions. Corn industry scientists are at work on new systems for producing industrial necessities from the versatile corn plant. ◀

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## BIOPRODUCTS

The term bioproducts designates a wide variety of corn refining products made from natural, renewable raw materials which replace products made from non-renewable resources or which are produced by chemical synthesis. The most widely known bioproduct is **ethanol** - a motor fuel additive fermented from corn. Ethanol has become such an integral part of our economy it deserves a page of its own. Ethanol has been made from grain for thousands of years, but it is only in the last 20 years that it has achieved widespread use as a motor fuel ingredient.

Fermentation of corn-derived dextrose has created an entirely a new group of bioproducts: organic acids, amino acids, vitamins and food gums.

Citric and lactic acid from corn can be found in hundreds of food and industrial products. They provide tartness to foods and confections, help control pH and are themselves feedstocks for further products.

Amino acids from corn provide a vital link in animal nutrition systems. Most grain feeds don't have the amount of lysine required by swine and poultry for optimal nutrition. Economical corn based lysine is now available worldwide to help supplement animal feeds. Threonine and tryptophan for feed supplements also come from corn.

Vitamin C and Vitamin E - vital human nutritional supplements - are now derived from corn, supplanting old production systems which relied on chemical synthesis. Even well-known food additives such as monosodium glutamate and xanthan gum are now produced by fermenting a dextrose feedstock.

Today's world is awash in plastic waste. Corn refiners now have fully commercial products to help deal with the plastic disposal problem and are developing an increasing array of degradable plastic products.

Extrusion, the same process used to make snack foods, can alter the physical structure of corn starch to make totally biodegradable packaging peanuts such as Eco-foam™. Other biodegradable plastics such as Eco-Pla™ are being made by modification of lactic acid. ◀

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## CORN OIL

By removing free fatty acids and phospholipids from crude corn oil, the oil refining process gives corn oil one of the qualities consumers value most: its excellent frying quality and resistance to smoking or discoloration. It also has a pleasant taste, resists developing off-flavors and offers high levels of polyunsaturated, instead of saturated fats.

Studies using typical American foods have found that no vegetable oil is more effective than corn oil in lowering blood cholesterol levels.

A majority of U.S.-produced corn oil goes into cooking or salad oil. A significant portion also goes into margarines and shortenings, while restaurants are using a growing amount to replace animal fats in frying operations. ◀

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## FEED PRODUCTS

Through different combinations of steepwater, corn germ residues, fiber and corn gluten, corn refiners produce four major feed products: gluten meal, gluten feed, corn germ meal and condensed fermented corn extractives (steepwater).

Corn gluten meal supplies vitamins, minerals and energy in poultry feeds; pet food processors value it for its high digestibility and low residue. Steepwater is a liquid protein supplement for cattle and is also used as a binder in feed pellets, and corn gluten feed provides protein and fiber for beef cattle.

Corn derived feed ingredients are one of America's leading agricultural exports. More than \$600 million of corn gluten feed and corn gluten meal are exported each year, strengthening the U.S. balance of payments. ◀

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