Background Report Reference

AP-42 Section Number: 9.11.1

Background Chapter: 2

Reference Number: 12

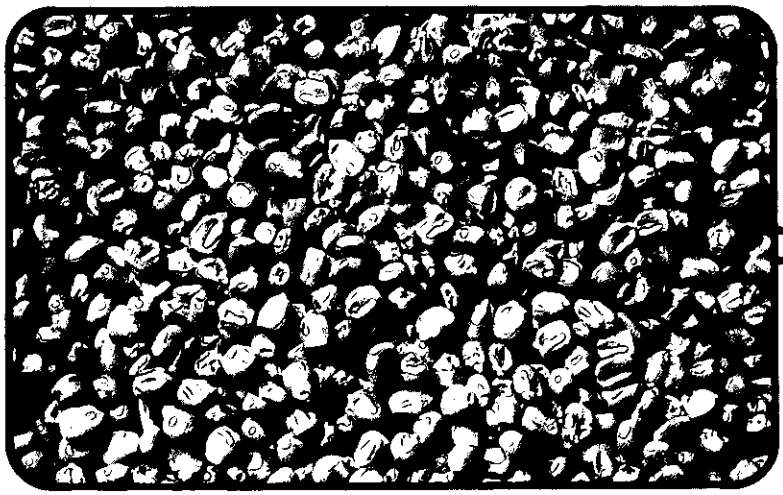
Title: Corn Refining: The Process, The Products

Corn Refiners Association Inc.

Corn Refiners Association, Inc.

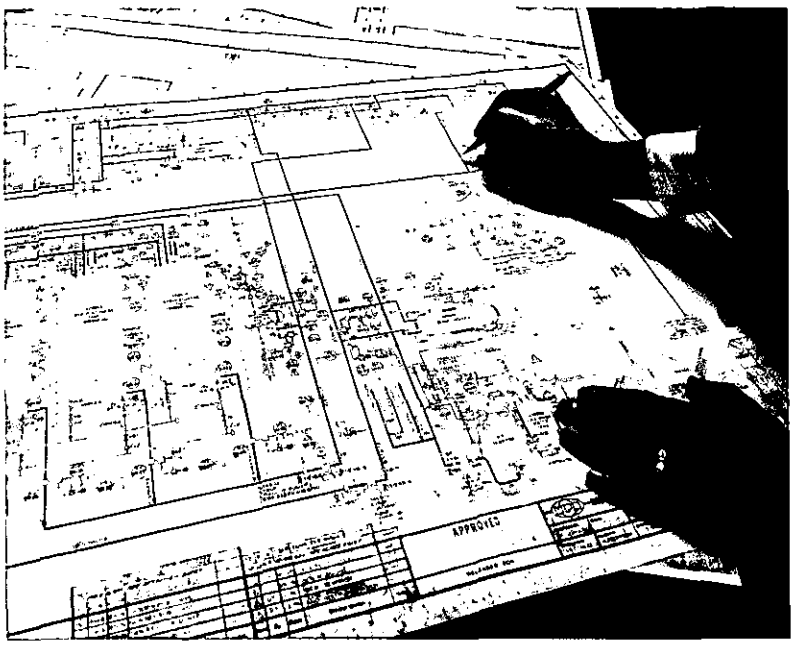
1992

C O R N REFINING



THE PROCESS, THE PRODUCTS

REFINING PLANTS



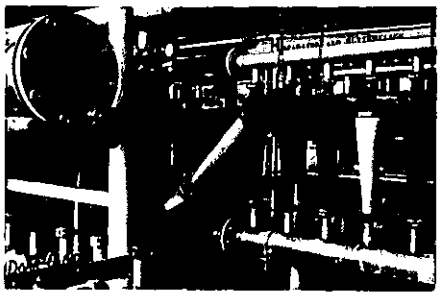
Corn, the distinctly American crop. Developed by the Indians, roasted at the Fourth of July picnic, produced with unparalleled efficiency and dedication by American farmers. Of every six bushels sold, corn refiners buy one for processing into the syrups, starches, oil, animal feeds, and alcohol which underlie thousands of food and industrial products in our world. In an average year over one billion bushels of shelled field corn travel from individual farms and elevators by truck, train and barge to 27 corn refining plants. This is the story of the process the corn will enter and the products that flow from it.

Most refining plants have been built or modernized since 1970, and the typical plant is both new and technologically innovative. Corn refiners design their plants for computer control throughout the process stream. Technicians can fine-tune pressures, temperatures, flow rate, ingredients, and chemical processes at every step to assure consistent, pure products achieved with maximum energy efficiency and minimal waste. An industry which, 100 years ago, produced only starch, has developed economic uses for the steepwater, gluten (protein), hulls and fiber which were once discarded. And, in their own labs and through CRA-sponsored scientific research, corn refiners constantly search for new technologies and more uses which will squeeze even more value out of every bushel of American corn.

STEEPING

Refinery staff inspect arriving corn shipments and clean them twice to remove cob, dust, chaff, and foreign materials before steeping, the first processing step begins. Each steep, a stainless steel vat, holds about 3,000 bushels of corn for 30 to 40 hours of soaking in 50 degree water. During steeping, the kernels absorb water, increasing their moisture levels from 15% to 45% and more than doubling in size. The addition of 0.1% sulfur dioxide to the water prevents excessive bacterial growth in the warm environment. As the corn swells and softens, the mild acidity of the steepwater begins to loosen the gluten bonds within the corn and release the starch. After steeping, the corn is coarsely ground to break the germ loose from other components. Steepwater is condensed to capture nutrients in the water for use in animal feeds. The ground corn, in a water slurry, flows to the germ separators.

GERM SEPARATION



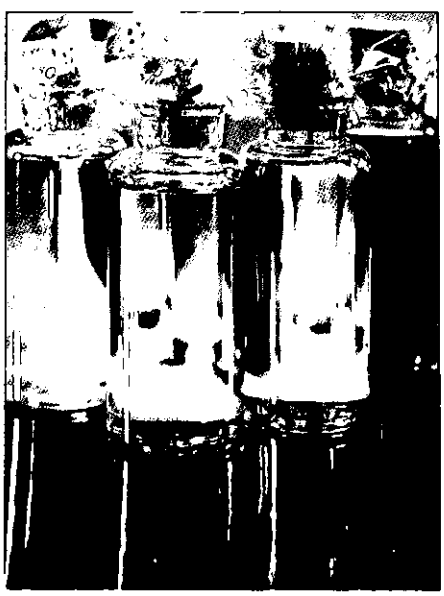
OIL REFINING

Cyclone separators spin the low density corn germ out of the slurry. The germs, containing about 85% of corn's oil, are pumped onto screens and washed repeatedly to remove any starch left in the mixture. A combination of mechanical and solvent processes extracts the oil from the germ. The oil is then refined and filtered into finished corn oil. The germ residue is saved as another useful component of animal feeds.

CORN OIL

By removing free fatty acids and phospholipids, 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. No studies using typical American foods have found any vegetable oil that is more effective than corn oil in lowering blood cholesterol levels.

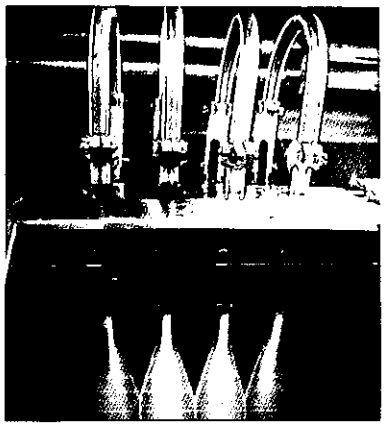
About half the U.S.-produced corn oil goes into cooking or salad oil. Popular corn oil margarines take another 25 percent, while restaurants are using a growing amount to replace animal fats in frying operations.



FINE GRINDING

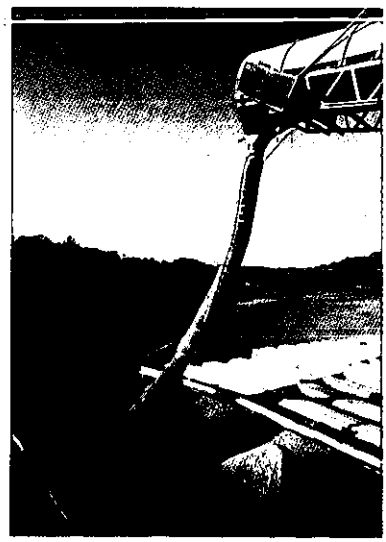
The corn and water slurry leaves the germ separator for a second, more thorough, grinding in an impact or attrition-impact mill to release the starch and gluten from the fiber in the kernel. The suspension of starch, gluten and fiber flows over fixed concave screens which catch fiber but allow starch and gluten to pass through. The fiber is collected, slurried, and screened again to reclaim any residual starch or protein, then piped to the feed house as a major ingredient of animal feeds. The starch-gluten suspension, called mill starch, is piped to the starch separators.

SCREENING



FEEDS

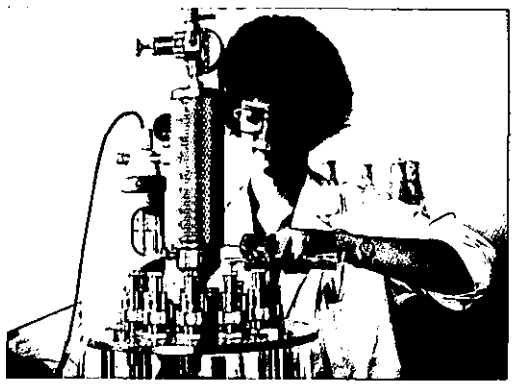
Through different combinations of steepwater, corn germ residues, fiber, and corn gluten, corn refiners produce four major feed products: gluten meal, gluten feed, corn germ meal, and condensed fermented corn extractives (steepwater). Although co-products of starch production, they use 25 to 30% of the corn processed and are important ingredients for feed formulating companies. 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.



STARCH SEPARATION

Gluten has a low density compared to starch. By passing mill starch through a centrifuge, the gluten is readily spun out for use in animal feeds. The starch, with just one or two percent protein remaining, is diluted, washed 8 to 14 times, rediluted and washed again in hydroclones to remove the last trace of protein and produce high quality starch, typically more than 99.5% pure. Some of the starch is dried and marketed as unmodified corn starch, some is modified into specialty starches, but most is converted into corn syrups and dextrose.

THE CHEMISTS



The corn refining process has been called half science and half art. Science because the processes are based on precisely calculated chemical reactions, and art because it takes a flair for orchestrating both the fine detail and the overall production scheme of a large-scale industrial enterprise. In recent years, however, the art has begun to take a back seat to the precision of the scientist.

These "Chemists of the Kernel" come from all academic disciplines drawn to the corn refining industry by the opportunity to use the most advanced production techniques developed in university laboratories. The science of enzymology finds its major commercial application in the production of corn sweeteners. Major techniques in industrial energy conservation coming from our major academic engineering centers are finding their first uses in corn refining plants. And, analytical methods and instruments developed by our major medical centers are being routinely used for monitoring production quality in corn refining plants.

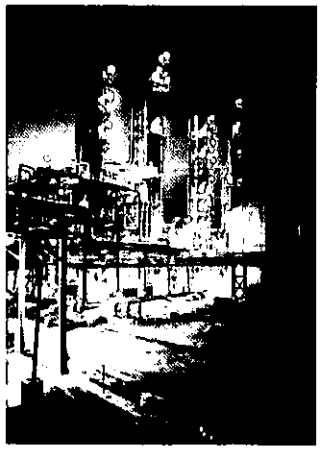
STARCHES

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.

FERMENTATION

In yet another application to corn refining, enzymes modify corn syrup from the converters to produce a high dextrose feedstock suitable for traditional fermentation methods. The result of the fermentation is ethanol, which corn refiners distill to remove excess water and sell for use in industry and in beverages. Carbon dioxide a by-product of fermentation, is also sold to beverage manufacturers as the "fizz" in soft drinks.

ALCOHOL



While ethanol is used in many ways, the primary demand for it comes from gasoline companies. First touted as a fuel extender, ethanol's use is growing now because it enhances fuel octane, improving engine performance. Ethanol's octane enhancing qualities have proved even more valuable because it is a safe alternative to lead additives which have been phased out and because it can help reduce ozone and carbon monoxide pollution.

SYRUP CONVERSION

Starch, suspended in water, is liquified in the presence of acid and/or enzymes which convert the starch to a low-dextrose solution. Treatment with another enzyme continues the conversion process. Throughout the process, refiners can halt acid or enzyme actions at key points to produce the right mixture of sugars like dextrose and maltose for syrups to meet different needs. In some syrups the conversion of starch to sugars is halted at an early stage to produce low-to-medium sweetness syrups. In others the conversion is allowed to proceed until the syrup is nearly all dextrose. The syrup is refined in filters, centrifuges and ion-exchange columns, and excess water is evaporated. Syrups are sold directly, crystallized into pure dextrose, or processed further to create high fructose corn syrup.

THE ENZYMES

To many, the word "enzymes" conjurs up images of Merlin-like substances, working their mysterious ways inside the human body. Stripped of their mystique, however, enzymes, a form of protein, are most efficient catalysts for biological reactions—in human metabolism and industrial production.

The breakdown of starch into sugars is at the heart of the growth of corn sweetener production. A host of commercially-produced enzymes serves as catalysts for the conversion of starch molecules into glucose and fructose, the most important sugars of human nutrition. Although some of these conversion processes can be accomplished by acid hydrolysis, the conversion of glucose into the sweeter sugar fructose was made possible by the discovery of the enzyme *glucose isomerase*. Other enzymes used by corn refiners are *alpha-amylase* which acts similarly to the amylase produced by the human digestive system, breaking down starch into glucose, and *glucoamylase* which speeds the full conversion of weak glucose solutions into pure dextrose.

Although enzymes are used in numerous food and industrial processes, in this day of daily advances in biotechnology, the corn refining industry remains the major user of biological processes for production of food and industrial products.

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 hotdogs, 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.

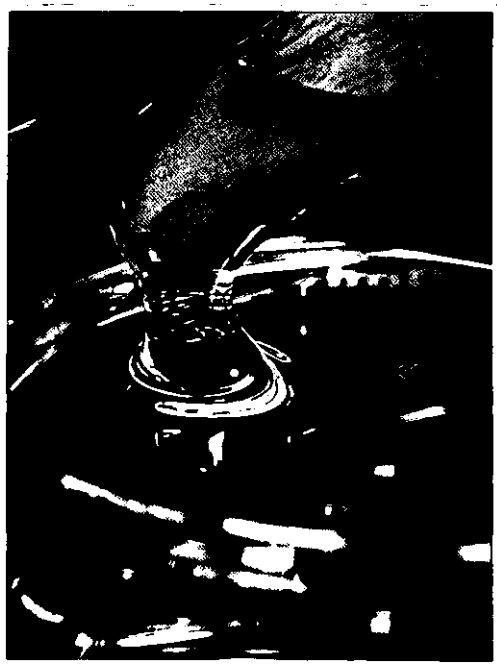
DEXTROSE

Dextrose is highly nutritious and easily digested because of its purity and because it is a standardized food form of glucose, the basic type of 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 pharmaceutic 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 SWEETENERS

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



MEMBER COMPANIES AND PLANT LOCATIONS

ADM Corn Processing
(A division of Archer Daniels Midland Company)
P.O. Box 1470
Decatur, Illinois 62525
Plants: Cedar Rapids, Iowa 52404
Clinton, Iowa 52732
Decatur, Illinois 62525
Montezuma, New York 13117

American Maize-Products Company
250 Harbor Plaza Drive
Box 10128
Stamford, Connecticut 06904
Plants: Decatur, Alabama 35601
Dimmitt, Texas 79027
Hammond, Indiana 46320

Cargill, Incorporated
P.O. Box 9300
Minneapolis, Minnesota 55440
Plants: Cedar Rapids, Iowa 52440
Dayton, Ohio 45413
Eddyville, Iowa 52553
Memphis, Tennessee 38113

CPC International Inc.
International Plaza
P.O. Box 8000
Englewood Cliffs, New Jersey 07632
Plants: Argo, Illinois 60501
Stockton, California 95206
Winston-Salem, North Carolina 27107

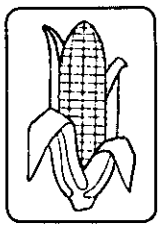
Minnesota Corn Processors
P.O. Box 1236
Marshall, Minnesota 56258
Plants: Columbus, Nebraska 68601
Marshall, Minnesota 56258

National Starch and Chemical Company
10 Finderne Avenue
Bridgewater, New Jersey 08807
Plants: Indianapolis, Indiana 46221
North Kansas City, Missouri 64116

Penford Products Co.
(A division of PENWEST)
P.O. Box 428
Cedar Rapids, Iowa 52406
Plant: Cedar Rapids, Iowa 52406

Roquette America, Inc.
1417 Exchange Street
Keokuk, Iowa 52632
Plant: Keokuk, Iowa 52632

A. E. Staley Manufacturing Company
(A subsidiary of Tate & Lyle, PLC)
P.O. Box 151
Decatur, Illinois 62525
Plants: Decatur, Illinois 62525
Lafayette, Indiana 47905 (2)
Loudon, Tennessee 37774



CORN REFINERS ASSOCIATION, INC.

1100 Connecticut Ave., N.W.
Washington, D.C. 20036
202-331-1634

Based in Washington, D.C., the Corn Refiners Association, Inc., is the national trade association representing the corn refining (wet milling) industry of the United States. The Association, and its predecessors, have served this important segment of American agribusiness since 1913.

Through a series of operating committees of executives from corn refining firms, the Association conducts programs of research and technical service, public relations and government relations for the Association membership. The Association is a primary source of educational material on corn and products from corn for schools, government, journalists, agriculture and agribusiness. Through assessments of the membership, the Association conducts a program of sponsored research at leading universities in the corn belt and throughout the country. Technical services of the Association assist the membership in meeting government regulations, in developing analytical methodology for use by the industry and users of products from corn and in relations with other trade and professional groups.

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